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U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards

COMPF2--A Program for Calculating Post-Flashover Fire Temperatures

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NOMENCLATURE

A	area (m^2)
b_p	combustion efficiency (-)
C_d	discharge coefficient (-)
C_p	heat capacity ($J\ kg^{-1}\ K^{-1}$)
D	smallest fuel dimension (m)
g	gravitational acceleration ($m\ s^{-1}$)
h	convective coefficient ($W\ m^{-2}\ K^{-1}$)
h	enthalpy (J)
h_c	combustion enthalpy (J)
Δh_c	calorific value ($J\ kg^{-1}$)
Δh_p	total heat of pyrolysis ($J\ kg^{-1}$)
k	thermal conductivity ($W\ m^{-1}\ K^{-1}$)
m	mass (kg)
M_o	initial fuel mass (kg)
q	heat (J)
Q	heat flow (W)
r	stoichiometric air/fuel ratio (-)
T	temperature (K)
v_p	regression velocity ($m\ s^{-1}$)
w	molecular weight ($kg\ mol^{-1}$)
x	thickness dimension (m)
ε	emissivity (-)
ρ	density ($kg\ m^{-3}$)
σ	Stefan-Boltzmann constant ($W\ m^{-2}\ K^{-4}$)

Subscripts

air	air
b	vaporization
ep	excess pyrolysate
f	hot gases; pool
o	ambient
p	pyrolysis
r	window radiation
v	ventilation, window
w	walls, including ceiling

Superscripts

	time rate
'''	per volume

COMPF2--A PROGRAM FOR CALCULATING
POST-FLASHOVER FIRE TEMPERATURES

Vytenis Babrauskas

COMPF2 is a computer program for calculating the characteristics of a post-flashover fire in a single building compartment, based on fire-induced ventilation through a single door or window. It is intended both for performing design calculations and for the analysis of experimental burn data. Wood, thermoplastic, and liquid fuels can be treated. In addition to the capability of performing calculations for compartments with completely determined properties, routines are included for calculating fire behavior by an innovative variable abstraction method. A comprehensive output format is provided which gives gas temperatures, heat flow terms, and flow variables. The documentation includes input instructions, sample problems, and a listing of the program. The program is written in Fortran and constitutes an improved version of an earlier program, COMPF.

Key words: Computer programs--fire protection; fire protection; fire resistance; fire tests; fire walls; safety engineering--fires.

1. INTRODUCTION

With increasing efforts [1-4][1] towards rational methods of providing fire endurance for structural building components, it becomes highly desirable for both the designer and the researcher to have available computer programs for calculating expected fire temperatures and heat transfer through the building components. A fire is not considered as becoming a threat to a structure and its fire barriers until it reaches the flashover stage. Flashover of a room is defined as that fire stage when the bulk of the room volume becomes involved in flames. Operationally, this roughly coincides with flames coming out the door or window, or an upper gas space temperature of around 600° C, or a radiant heat flux at floor level of about 20 kW/m^2. For the purpose of designing for fire endurance, then, only post-flashover fires are considered. The present report describes a computer program for calculating the expected temperatures, heat and mass flows and other variables in post-flashover building fires. Different routines are incorporated for producing design time-temperature curves and for permitting comparative theoretical curves to be generated based on experimental mass loss rates.

2. HISTORY OF DEVELOPMENT

The first computer program for calculating post-flashover fire temperatures was developed by Kawagoe [5], in conjunction with his pioneering studies leading to a theoretical room fire model. This model was an adaptation of an earlier graphical technique. The main limitations of both the computer program

[1] Numbers in brackets refer to the literature references listed at the end of this paper.

and the theoretical model was the restriction to ventilation-limited fires. Fuel-limited fires could only be expressed in terms of an empirical temperature change rate. Magnusson and Thelandersson [6] studied heat release rates in more detail and produced a model. An unpublished computer program was used to implement that model. The normalized shape of the fire time-temperature curves was an input variable in this model; the shape was based on sets of typical measurements. Based on Magnusson and Thelandersson's theory, Fedock [7] published a similar computer program with emphasis on prestressed concrete structures. The first program to provide for theoretically based calculations of both ventilation-limited and fuel-limited burning was written by Tsuchiya [8]. It was restricted to fires starting in ventilation control and to fuel consisting of sparsely-packed wood sticks.

The predecessor to the present program, COMPF [9], was issued in 1975 and incorporated several new advances, including the ability to treat entirely fuel-limited fires, to allow for temperature-dependent wall properties, to permit the optional use of numerical input fuel weight loss rates, and to perform certain variable abstraction ("pessimization") calculations as an aid to design. (These techniques enable an input variable to be treated non-deterministically.) Program COMPF2 is intended to replace program COMPF and differs from it in the following main ways:

1. A subroutine has been added to allow treatment of fires where thermoplastic or liquid fuel exists in the form of a pool on the floor. The routine implements the theory discussed in reference [10] and outlined in section 4.1; examples of calculations are also given and discussed in that reference.

2. The deterministic wood fuel burning model has been extended to include the possibility of densely-packed cribs.

3. Both pool fire and densely-packed crib options have been incorporated into the pessimization routines.

4. In addition to performing transient calculations, the program can now also treat steady-state solutions, for both lossy and adiabatic walls.

5. The program is now in S.I. units throughout.

6. Certain corrections and improvements have been incorporated in the calculation routines. The method for the iterative solution of the heat balance equation has especially been improved.

3. THEORY

The post-flashover compartment fire theory has been given in some detail in reference [11], thus, only a brief summary will be given here. The main assumptions are:

- The compartment represents a well-stirred reactor, i.e., spatial temperature variations in the hot fire gases are ignored.

- The model is quasi-steady. Time variations in fuel release rate and in conduction losses are fully included. However, time rate of change terms in gas phase mass and energy balance are dropped.

- Air supply and gas outflow is through a single window in a vertical wall and is the result of fire-induced convection.

- The thermal discontinuity away from the window region is at a level below the bottom of the window. The volume below the discontinuity is occupied

by cold incoming air. In a flashed-over fire this discontinuity is close to the floor. Its exact location below the window bottom is immaterial [12].

- Burning is limited by rates of air or fuel supply rather than by gas phase chemical kinetics.
- Walls (including the ceiling) are modeled as portions of a homogeneous solid of finite thickness. Temperature-dependent material properties are allowed for.

The heat balance equation is:

$$\dot{h}_c - \dot{m}_f \left(h_{T_f} - h_{298}\right) - Q_w - Q_r - Q_{ep} = 0 \tag{1}$$

where h denotes enthalpy and the definition of symbols is given in the Nomenclature section. The subscripts on the enthalpy terms denote the temperature at which they are evaluated. The window radiation loss is, simply

$$Q_r = A_v \, \sigma \, (T_f^4 - T_o^4) \tag{2}$$

The wall loss term has a radiative and a convective component,

$$Q_w = A_w \left[\sigma \, \frac{1}{1/\varepsilon_f + 1/\varepsilon_w - 1} \, (T_f^4 - T_w^4) + h \, (T_f - T_w)\right] \tag{3}$$

The convective coefficient h above is not well known since the exact flow conditions at the wall and ceiling surfaces in a post-flashover fire are not known in detail. The convective fraction is much less than the radiative fraction, permitting a rather simplified treatment. For turbulent-free convection flow over flat plates the value for h should depend [13] on $(T_f - T_w)^{1/3}$. A value of

$$h = 5.0 \, (T_f - T_w)^{1/3} \tag{4}$$

was selected as being in reasonable agreement with data.

The analysis in [11] shows that for compartments greater than about 2 m on a side, a flame emissivity of $\varepsilon_f \approx 0.9$ may be used.

The enthalpy evolved from combustion, $\dot{h}_c$, must be evaluated as the lesser of

$$\dot{m}_p \, \Delta h_c \, b_p \tag{5}$$

or

$$\dot{m}_{air} \, \frac{\Delta h_c}{r} \, b_p. \tag{6}$$

When equation (5) is limiting, the combustion is known as "fuel-limited", while if equation (6) is smaller, combustion is "ventilation-limited". Here b_p represents the maximum combustion efficiency and is a largely unknown number. Since it represents, effectively, the "unmixedness" of the combustion, there may be a scale effect, with smaller compartment spaces showing less complete mixing. Experimental data can generally be correlated within a range of about $0.7 \leq b_p \leq 0.9$.

The value of $\dot{m}_{air}$ is obtained from the Bernoulli equation at the window and is

$$\dot{m}_{air} = \frac{2}{3} C_d \rho_o \left[2g \frac{1 - W_f T_o / W_o T_f}{[1 + (W_o T_f / W_f T_o [1 + (\dot{m}_p / \dot{m}_{air})]^2)^{1/3}]^3} \right]^{1/2} A_v \sqrt{h}_v. \quad (7)$$

The discharge coefficient has been determined by Prahl and Emmons [14] to be 0.68 for normal-shaped windows. This value does not hold in cases where the window takes up almost an entire wall. For such windows the flow patterns have not been studied, but data can be correlated by taking C_d at about one-half its normal value. The molecular weight of the products, W_f, is not exactly known since the composition of the gases, especially the unburned fuel gases (excess pyrolysates) is generally unknown. For simplicity their molecular weight has been assumed equal to that of nitrogen. The contribution of carbon monoxide and other minor combustion products is also ignored. The main dependence of $\dot{m}_{air}$ is on the window parameter $A_v \sqrt{h}_v$. For reasonable values of temperature the whole expression becomes approximately equal to

$$\dot{m}_{air} \simeq (0.45 \text{ to } 0.50)\, A_v \sqrt{h}_v \quad (8)$$

But this approximation has not been employed here.

Ventilation through multiple openings has not been provided for in this program. An approach for treating such problems is given in [11].

The heat of combustion, Δh_c, is taken as the net value since the hot gas outflow is above 100° C. The stoichiometric ratio, r, is a constant for a pure material; a tabulation of values is given in [15].

The rate of pyrolysis, $\dot{m}_p$, is one of the hardest quantities to determine. A discussion of available values is given in the next section.

The outflow mass rate, $\dot{m}_f$, is by mass conservation the sum of $\dot{m}_{air}$ and $\dot{m}_p$. The enthalpy of the outflow products, h_{T_f} and h_{298} is evaluated on the assumption that the combusted fuel goes to CO_2 and H_2O. No account is taken of CO for two reasons: because the effect on a mass basis would be very small, and because it was considered advisable not to introduce any reaction kinetics. Also, only elements C, H, O, and N have been considered for the fuel composition.

The excess pyrolysate term Q_{ep}, is the heat required to vaporize the excess pyrolysates. Note that with the conventional definition of heat of combustion, the loss for vaporization of combusted pyrolysates is already included in Δh_c.

The second major equation to be solved is for heat conduction through the wall.

$$\rho C_p \frac{\partial T_w}{\partial t} = \frac{\partial}{\partial x}(k \frac{\partial T_w}{\partial x}) + \dot{q}''' \tag{9}$$

The wall is initially at ambient temperature, T_o, and is subjected to boundary conditions at the fire side of:

$$-k \frac{\partial T_w}{\partial x} = h [T_f - T_w(o)] + \epsilon\sigma [T_f^4 - T_w^4(o)] \tag{10}$$

and on the unexposed side (x = L),

$$-k \frac{\partial T_w}{\partial x} = h [T_w(L) - T_o] + \epsilon\sigma [T_w^4 (L) - T_o^4] \tag{11}$$

For the fire side the convective coefficient has been given above. For the unexposed side a value of

$$h = 1.87 \quad [T_o - T_w (L)]^{1/3} \tag{12}$$

was taken.

4. PYROLYSIS RATES

4.1 Liquid or Thermoplastic Pools

There is currently only one fuel arrangement where the pyrolysis rate may adequately be predicted from theory. It consists of a pool of thermoplastic or liquid fuel on the floor. The fuel is pyrolyzed solely by radiant flux and "sees" the compartment with a view factor of 1.0 and itself with a view factor of zero. In addition, the fuel must pyrolyze at a known surface temperature, T_b, and with a known heat of pyrolysis, Δh_p. Then:

$$\dot{m}_p = A_f \frac{\epsilon\sigma \ (T_f^4 - T_b^4)}{\Delta h_p} \tag{13}$$

Tewarson and Pion [16] have measured heats of pyrolysis for numerous thermoplastic materials.

The above simple model is fully adequate for steady-state solutions. At the start of the fire, however, the radiation feedback is small from the hot gas volume but may be larger from the local plume above the pool itself. Thus, a plume term should be added in to model the starting transient. Very limited experimental data by Burgess [17] and by Modak [18] can be used to derive an empirical relationship for the plume pyrolysis rate as:

$$\dot{m} = A_f \ 0.0014 \frac{\Delta h_c}{\Delta h_p} \quad (kg/s) \tag{14}$$

This relationship does not take into account differences in flame emissivities for various materials; as a result, it only provides a crude measure. In the present application, however, the contribution of this term is minor; therefore, an approximate expression is adequate. Also, as the room radiation increases, the effect of plume radiation on pyrolyzing the

fuel decreases. For a radiatively black room, at high temperature, the plume term should properly be negligible. This interaction is crudely modeled by multiplying the plume term by a proportionality factor before adding to the far-field term. The proportionality factor, χ, has been set equal to

$$\chi = 1.0 - \frac{T_f^4 - T_b^4}{1700^4 - T_b^4} \tag{15}$$

with $\chi \geq 0$.

4.2 Solid Fuels

Empirical data are available for the mass loss rates of wood planks in flashed-over fires. Because of the nature of wood combustion, these rates are not especially sensitive to room radiation and can be specified [11] using a regression velocity of 7-15 μm/s. This relationship is adequate to describe the burning of large, isolated wood panels. For pieces thin in two or three dimensions, yet still widely spaced, the following expression is suitable:

$$\frac{\dot{m}_p}{M_o} = \frac{F}{C} \left(\frac{m}{M_o} \right)^{1-1/F} \tag{16}$$

Here M_o is the original mass, m is the mass at a given time, and F is a constant equal to 2 for cylinders or rectangular sticks and equal to 3 for spheres or cubes. C is given by

$$C = \frac{D}{2v_p}$$

with D being the smallest fuel dimension and v_p the regression velocity. For thin fuels v_p is approximately

$$v_p \simeq 1.7 \times 10^{-6} D^{-0.6} \text{ (m/s)} \tag{17}$$

The final arrangement for wood fuel for which data are available is a crib, or a regular stacked array. From the data of Nilsson [19] and Yamashika [20], a set of simplified relationships has been evolved for the three crib burning regimes.

<u>Fuel Surface Control</u>

$$\dot{m}_p = \frac{4}{D} v_p \left(\frac{m}{M_o} \right)^{1/2} M_o \qquad \text{(kg/s)} \tag{18}$$

$$v_p = 1.7 \times 10^{-6} D^{-0.6}$$

Crib Porosity Control

$$\dot{m}_p = 4.4 \times 10^{-4} \ ({}^{S}/_{h_c}) \ \frac{M_o}{D} \qquad (19)$$

${}^{S}/_{h_c}$ = ratio of stick clear spacing to crib height

Room Ventilation Control

$$\dot{m}_p = 0.12 \ A_v \sqrt{h_v} \qquad (20)$$

In calculations, each of the three rates above are determined and the lowest rate taken as governing.

5. DETAILS OF SUBROUTINES

The program routines are written in Fortran language. A complete listing is given in appendix B. The following are brief descriptions of the operation of each subroutine.

5.1 COMPF2

COMPF2 is the main program. It calls most of the calculational routines. A flow chart of COMPF2 is given in figure 1. The program starts with the initialization of certain constants and default values. The input title and namelist are then read in. If tabular data are specified, subroutine INC is called. ICONDS is then called in to set initial starting values. The input data are echoed in ECHOID. After that, the appropriate computational routine is called in. If no iteration failure has occurred the program then loops back to the start and goes to the next problem. In case of iteration failure, the program returns to the same problem, this time printing out additional intermediate calculation values. This intermediate output can also be forced to appear by specifying KTRACE=1.

5.2 CRIB

Subroutine CRIB calculates the burning of wood crib fires. A trial gas temperature value is assumed for the first time step. This value is preset, but may be overridden by specifying a value of TINPT. The flow quantities are computed, then the wall losses are determined by calling DESOLV. The heat balance is then determined. If the normalized residue is greater than 0.002, the iteration continues. The new temperature is normally determined by the Newton method. If divergence results, a scanning technique is used initially and a splitting of differences once a bounded oscillation results. After successful convergence a new wall temperature profile is established by calling RSTA. The calculation then proceeds to the next time step. Computation is terminated at the end of time MTIME, or when gas temperature drops to 353 K, or if errors or convergence failure is detected.

5.3 DEQNS

Subroutine DEQNS computes wall heat conduction using the Crank-Nicolson method [21]. DEQNS has two entry points: DESOLV and RSTA. The radiation boundary condition is linearized; updating every iteration rather than every time step ensures minimal error. An additional within-loop iteration is also used. DEQNS calls TRIDGF to solve the equation matrix.

5.4 ECHOID

Subroutine ECHOID echoes the input data. The complete data set is given for each run, rather than just the changed values. Care has been taken to give physical meaning for the variables printed.

5.5 ICONDS

Subroutine ICONDS initializes starting values and does some preliminary calculations on the input data. It also makes a few checks on the validity of the input data. The user, however, is cautioned that this checking is very rudimentary and in case of error exit or iteration failure the input data must be carefully examined.

5.6 INC

Subroutine INC is called in when tabular input data are to be read.

5.7 OUTPUT

Subroutine OUTPUT is the primary output routine. It writes at each time step a large number of variables to output files (logical units) 2 and 3. The temperatures, burning rates, and other primary variables are put on file 2, while the heat balance values and the mass fractions are written on file 3. OUTPUT also converts temperatures from Kelvin to degrees Celsius before printing them out.

5.8 PFLFIX

PFLFIX is a pessimization design routine. Fuel pyrolysis rate is calculated according to governing equations, but the ventilation is pessimized by instantaneously adjusting the window width to give the highest possible temperatures. Wood stick or wood crib fuel is assumed unless PLFUEL=T, in which case a pool fire is used. The window width is not allowed to exceed a maximum, as set by AWDOW/HWDOW. Calculations stop when the fuel, as specified by FLOAD, is exhausted, since the window width would be undefined beyond that point. Calculational procedures are similar to those in CRIB.

5.9 POOL

POOL is a pool fire burning routine. Computational details are similar to those as in CRIB. The pyrolysis rate is based on equations 13, 14, and 15. Three modes of subroutine operation are possible. If STOICH=T, the steady-state temperatures and pool area are determined for stoichiometric burning. If EISCAN=T, the steady-state solution is found for a given pool area greater than stoichiometric. The pool area is specified by use of the parameter EITA, defined as [10]

$$\eta = \frac{\dfrac{A_v \sqrt{h_v}}{A_f}}{\left(\dfrac{A_v \sqrt{h_v}}{A_f}\right)_{stoich}} \tag{21}$$

For constant window size, this becomes simply a ratio of pool areas. No solutions are possible for $\eta \geq 1$. Finally, a transient calculation can be made, which proceeds similarly as in the other transient calculations. The user must make sure that the pool size given is sufficiently large so that $\eta \leq 1$.

5.10 PP

Subroutine PP is a plotting routine. Details are not given since plotting routines are dependent on the hardware used.

5.11 PVTFIX

PVTFIX is a pessimization routine, and is effectively the inverse of PFLFIX. In PVTFIX a fixed ventilation opening is specified. The fuel release rate is instantaneously varied to always result in the highest possible burning temperature. Temperatures drop after the fuel load is consumed. Computational details are similar to those in PFLFIX.

5.12 RPFIX

For comparison of measured data against numerical predictions a routine is needed which can accept $\dot{m}_p$ rates as an input tabular function of time. RPFIX provides for this type of checking calculation. The case of measured combustion rate input (as provided, for instance, by oxygen depletion measurements in the window outflow) can also be treated by dividing the measured rate by Δh_c (net) and setting $b_p = 1.0$.

5.13 STFLOW

Subroutine STFLOW is a wall heat conduction routine. It is similar to DEQNS, except that only the steady-state temperatures are determined.

5.14 TLU

Function TLU is a tabular data interpolating function used in several subroutines. If the independent variable entered is smaller than the smallest data point or larger than the largest data point, the output is set equal to the smallest, or largest dependent value, respectively.

5.15 TRIDGF

Subroutine TRIDGF uses a Gauss elimination procedure to solve a set of tri-diagonal matrix equations.

6. AGREEMENT WITH EXPERIMENT

A comparison of numerical predictions with experimental results has been given in [22] for the program COMPF. Similar agreement should hold for COMPF2, since COMPF2 is improved mainly in operational features, especially increased versatility, while retaining the same theoretical model as in COMPF. For pool fires useable full-scale experimental data are not available.

7. INPUT INSTRUCTIONS

7.1 Deck Set-up

The input is assigned to file 1. Each problem run consists of two or three card groups, as follows:

1. Title card (20A4). One card only. Card must be present. The identifying information from the title card is printed at the head of the output.

2. Namelist card(s). One or more cards. Details are given in the next section.

3. Tabular input (optional). This input group is contained only for the first run and for those ensuing runs where NEWPRP=T. If no tabular input is present, then blank cards must not be inserted. If tabular input is present, it is arranged as follows:

First card: NCN, NCP, NEM, NR, NQG (10I3). These are the number of points for the wall thermal conductivity, wall heat capacity, wall emissivity, mass pyrolysis rate, and wall heat generation rate, respectively. The number of points may be 0, 1, or greater than 1. If N=0, then the previous run value is unchanged. If N=1, then it is assumed the value is a constant, independent of temperature or time. If N$\geq$1, then an array is inputted.

Ensuing card(s): These are in the format (8F10.0) and arranged in pairs (independent, dependent). For wall thermal properties, temperature is the independent variable, while for mass pyrolysis rate it is time. The order is: CNDA, CPW, EMSA, RPX, QGEN. First all the points (if any) for CNDA are read in, four pairs per card. Then a new card is started even if the last card is part-full, and CPW is read in. The process is continued for EMSA, RPX, QGEN. No blank cards may be inserted. If N=1 for an array, then the constant value is entered in columns 11-20.

After cards for one run are finished, the cards for the next one are stacked, again with no blank cards.

7.2 Namelist VARS

For all non-tabular data, the namelist format was adopted. This undeservedly obscure Fortran feature is highly advantageous for the present application. Its features include:

- Semi free-format input
- Variables may be in any order
- Unneeded variable values need not be specified
- Variables needed, but not specified in current run are automatically set equal to the prior given value.

The namelist card(s) must contain the following information: the first card must start with $VARS in columns 2-6, then a space, then the desired values, separated by commas. Input may be continued on continuation cards, each of which must have columns 1-2 blank. The stream is terminated by a $ after the last variable.

The user is cautioned to check the input carefully, since namelist format provides for only rudimentary error messages. The namelist VARS values are written to file 5 when read in. In normal operation file 5 can be rewound or discarded. If error failures occur, however, the VARS listing on file 5 may be useful in determining input errors.

Table 1 lists all the variables inputted in namelist VARS.

7.3 Modes of Program Operation

Time

Three possibilities are available: complete time-temperature curve calculation, calculation of steady-state temperature for a given wall, or the calculation of a steady-state temperature for adiabatic walls. To select adiabatic walls, set ADIA=TRUE. To select steady-state solution for real walls,

set STEADY=TRUE. To obtain complete time-temperature curve, set ADIA and STEADY both FALSE. Note that for some fuel pyrolysis conditions below not all three possibilities are available.

Fuel Pyrolysis

The following modes of operations are available:

1) Pool fire
   Set PLFUEL=TRUE.

   a. Time-temperature curve for given ventilation and pool area. Specify SIZE. Set STOICH and EISCAN both FALSE.

   b. Burning conditions at steady state for stoichiometric pool size, that is, determine values for EITA=1. Set STOICH=TRUE. Do not input SIZE. Do not set EISCAN=TRUE.

   c. Burning conditions for any other EITA. Set EISCAN=TRUE. Specify EITA. This option must be preceded by the stoichiometric problem (option 1b, above). SIZE input is not used; if given, the value is disregarded.

2) Wood crib fire. This is the default option. Set FLSPEC, PLFUEL, RPSPEC, and VTSPEC all FALSE.

   a. Simple stick burning. Must specify a value for REGRES greater than zero.

   b. Nilsson's crib formulas for crib burning in three possible regimes. Specify REGRES=0. (default). Also specify SH.

3) Checking option when tabular input pyrolysis rates are given. Set RPSPEC=TRUE. Also must set NEWPRP=TRUE and give an appropriate array of RPX.

4) Pessimization over ventilation. Set FLSPEC=TRUE. Window width is automatically adjusted, but is no greater than determined by the inputted value of AWDOW/HWDOW. Program stops when fuel is exhausted.

   a. Simple stick burning. Must specify a value for REGRES greater than zero and set PLFUEL=FALSE.

   b. Nilsson's crib formulas for crib burning in three possible regimes. Set PFLUEL=FALSE and REGRES=0. Also specify SH.

   c. Pool burning. Set PLFUEL=TRUE.

5) Pessimization over fuel pyrolysis rate. Set VTSPEC=TRUE. Fuel pyrolysis rate is automatically adjusted for pessimal burning conditions.

8. FILES USED

The Fortran file logical units must be declared as follows:

File 1 -- Input
File 2 -- Output (echoed input and main calculated variables)
File 3 -- Output (heat balance and mass fractions)
File 4 -- Output (intermediate tracing output - used only if KTRACE=1)
File 5 -- Output (listing of namelist VARS contents).

File 5 can be arranged to be rewound after each problem so that it will contain data only in case of error failure.

9. IMPLEMENTATION

Program COMPF2 has been successfully implemented on a UNIVAC 1108 computer. The predecessor program, COMPF, was run on a CDC 6400 computer. The program uses, as much as possible, only standard Fortran expressions. Minor unavoidable implementation differences exist, however, in commands associated with file usage.

10. LIST OF VARIABLES

Table 2 gives a list of all the major problem variables.

11. ACKNOWLEDGMENTS

Ulf Wickstrom (Lund Institute of Technology) assisted in program development; Richard Peacock (NBS) helped implement the program.

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Table 1. Variables specified in the input Namelist VARS

Variable	Default Values: First run	Default Values: Following run	Information
ADIA	FALSE	pv	if true, walls area adiabatic and only steady-state solution is sought
AFLOOR	none	pv	area of floor (m^2)
AWALL	none	pv	gross area of walls and ceiling (m^2)
AWDOW	none	pv	area of window (m^2)
BPF	none	pv	maximum fraction of pyrolyzed fuel burned to be ≤ 1.0
CD	0.68	pv	discharge coefficient
CFLPC	44.4	pv	percent, by weight, of carbon in fuel
CPPYR(2)	CPN2	pv	heat capacity of pyrolysis gases (J/kg-K)
CVGROS	none	pv	upper calorific value for dry fuel (J/kg)
DENSW	none	pv	wall density (kg/m^3)
DHP	none	pv	total heat of gasification for fuel (J/kg)
DTIME	none	pv	increment of time step (s)
EF	0.9	pv	gas emissivity, assumed gray
EISCAN	FALSE	FALSE	if true, solve steady-state problem in POOL for a given EITA
EITA	none	pv	normalized air-fuel parameter for pool burning
FLOAD	none	pv	fuel load (kg/m^2 floor area)
FLSPEC	FALSE	FALSE	if true, pessimize ventilation for a specified pyrolysis rate
HFLPC	5.4	pv	percent of hydrogen, by weight, in fuel
HWDOW	none	pv	window height (m)
IRUN	1	sequential	run problem number
IX	10	pv	number of wall slices, to be ≤ 10
KTRACE	0	0	print intermediate output if =1
MTIME	360.	pv	maximum fire time (s)
MWPYR	28.97	pv	molecular weight of pyrolysis gases (g/g-mole)
NEWPLT	FALSE	FALSE	if true, start new plot frame
NEWPRP	TRUE	FALSE	if true, new data arrays will be given
NFLPC	0.	pv	percent of nitrogen, by weight, in fuel
OFLPC	0.	pv	percent of oxygen, by weight, in fuel
PLFUEL	FALSE	FALSE	if true, fuel is a pool fire
PLOT	FALSE	pv	if true, plot time-temperature curve
PNCH	FALSE	pv	if true, punch time-temperature curve
PRNT	none	pv	interval at which results are to be printed (s)
REGRES	0.	pv	rate of fuel regression (m/s)
RPSPEC	FALSE	FALSE	if true, use tabular input fuel pyrolysis
SH	0	pv	ratio of clear spacing between sticks/crib height for crib
SHAPE	2.	pv	shape factor in pyrolysis equation for wood sticks
SIZE	none	pv	for cribs: smallest dimension of stick (m) for pools: pool area (m^2)
STEADY	FALSE	FALSE	if true, only steady-state solution is to be sought
STOICH	FALSE	FALSE	if true, EITA=1 solution is sought in POOL

Table 1. (continued)

TBOILC	0.	pv	fuel vaporization temperature for pools (C)
THICKW	none	pv	wall thickness (m)
TINPT	0.	0.	optional input iteration gas temperature (K)
VTSPEC	FALSE	FALSE	if true, pessimize pyrolysis rate for a specified ventilation
WFLPC	0.	pv	percent of water, by weight, in fuel

Note:

pv = previous value

Table 2. List of variables

ADIA	true if walls are adiabatic
AFLOOR	area of floor (m^2)
AWALL	gross area of walls and ceiling (m^2)
AWALLN	AWALL minus window area
AWDOW	area of window (m^2)
BPF	maximum fraction of pyrolyzed fuel burned
BWDOW	width of window (m)
BWORST	window width (.LE.BWDOW) which maximizes gas temperatures (m)
C	moles of carbon in fuel (mole/kg fuel)
CD	discharge coefficient
CFLDC	percent of carbon, by weight, in fuel
CND	conductivity of a given wall slice (W/m-K)
CNDA	conductivity of the wall, as a function of temperature (W/m-K)
CNG	average conductivity, next to higher numbered slice
CNL	average conductivity, next to lower numbered slice
CNV	numerical factor in heat transfer coefficient
CPA	heat capacity of ambient air (J/kg-K)
CPCO	heat capacity of CO, as a function of temperature (J/kg-K)
CPCO2	heat capacity of CO_2, as a function of temperature (J/kg-K)
CPH2	heat capacity of H_2, as a function of temperature (J/kg-K)
CPH2O	heat capacity of H_2O, as a function of temperature (J/kg-K)
CPN2	heat capacity of N_2, as a function of temperature (J/kg-K)
CPO2	heat capacity of O_2, as a function of temperature (J/kg-K)
CPPYR	heat capacity of pyrolysis gases, as a function of temperature (J/kg-K)
CPW	wall heat capacity, as a function of temperature (J/kg-K)
CVGROS	upper calorific value for dry fuel (J/kg)
CVNET	lower calorific value for moist fuel (J/kg)
DENF	Biot Number/2--fire side
DENSA	ambient air density (kg/m^3)
DENSW	wall density (kg/m^3)
DENU	Biot Number/2--unexposed side
DERIV1	current derivative of heat balance remainder (W/K)
DERIV2	previous derivative of heat balance remainder (W/K)
DIF	temperature error in iteration (K)
DTGAS	increment in gas temperature (K)
DTIME	time increment (s)
DX	wall thickness increment (m)
EF	effective flame grey body emissivity
EISCAN	true if seeking contant EITA≠1 solution
EITA	dimensionless air/fuel parameter for pool burning
EMS	computed wall emissivity for parallel plane problem
EMSA	wall emissivity, as a function of temperature
FC	true if in fuel control
FLOAD	fuel load (kg/m^2 of floor area)
FLREM	mass of fuel remaining at a given time (kg)
FLSPEC	true if fuel pyrolysis rate is fixed and ventilation pessimized
FUELPC	percent of original fuel supply still remaining
F1	current heat balance error (W)
F2	previous heat balance error (W)
G	acceleration of gravity (m/s^2)
H	moles of hydrogen in fuel (mole/kg fuel)
HCP	variable in solving differential equation
HF	effective heat transfer coefficient, fire side (W/m^2-K)
HFLPC	percent of hydrogen, by weight, in fuel
HU	effective heat transfer coefficient, unexposed side (W/m^2-K)
HIN	height of neutral plane (m)
HRATIO	fractional height of neutral plan above window bottom
HWDOW	height of window (m)
ILINE	line number

Table 2. (continued)

IPG	page number
IRUN	run number
IX	number of wall slices
IXC	number of middle slice
IXL	number of penultimate slice
J	number of current time step
JM	maximum number of time steps
JPRINT	output to be printed every JPRINT time steps
K	number of trial iterations at any given time step
KD	number of iterations to converge differential equation
KITER	equals 0 for normal operation, equals 1 for convergence failure
KNTRL	parameter indicating exit status
KTRACE	print intermediate tracing output if KTRACE-1
MTIME	maximum time for fire simulation (s)
MWIN	molecular weight of ambient air (g/g-mole)
MWOUT	molecular weight of exhaust gases (g/g-mole)
MWPYR	molecular weight of pyrolysis gases (g/g-mole)
N	moles of nitrogen in fuel (mole/kg fuel)
NCND	number of points in CNDA table
NCPW	number of points in CPW table
NEMS	number of points in EMSA table
NEWPLT	true if start new plot frame (not overlay previous one)
NEWPRP	true if read in new set of tabular data
NFLPC	percent of nitrogen, by weight, in fuel
NQGEN	number of points in QGEN table
NRP	number of points in RPX table
O	moles of oxygen in fuel (mole/kg fuel)
OFLPC	percent of oxygen by weight, in fuel
OPENF	opening factor ration ($m^{2 \cdot 5}$)
PLFUEL	true if pool fire configuration
PLOT	true if plot time-temperature curve
PNCH	true if punch time-temperature curve
PRNT	number of times per second output is to be printed
QCONW	heat transfered to walls by convection (W)
QFIRE	heat generated by combustion (W)
QFLOW	net flow enthalpy (exhaust minus inflow) (W)
QFUEL	heat lost in heating up unburned fuel fraction (W)
QGEN	wall heat generation, as a function of temp (W/m^3)
QRADO	heat radiated out the window (W)
QFLOW	new flow enthalpy (exhaust minus inflow) (W)
QFUEL	heat lost in heating up unburned fuel fraction (W)
QGEN	wall heat generation, as a function of temp (W/m^3)
QRADO	heat radiated out the window (W)
QRADW	heat transfered to walls by radiation (W)
QWLSUM	total heat removed from compartment and passing into the walls (J)
R	stoichiometric air/fuel mass ratio
RO	stoichiometric oxygen/fuel mass ratio
RC	rate of burning (kg/s)
REGRES	rate of fuel surface regression (m/s)
RMA	mass inflow rate of air (kg/s)
RMF	mass outflow rate of hot gases (kg/s)
RP	rate of pyrolysis (kg/s)
RPSPEC	true if rate of pyrolysis is prescribed as input
RPX	rate of pyrolysis, as a function of time (kg/s)
SCAN	true if search for solution by scanning temperatures
SH	ratio of clear spacing between sticks to crib height
SHAPE	contant indicating shape of fuel sticks
SIGMA	Stefan-Boltzmann constant (W/m^2-K^4)
SIZE	thickness of crib sticks (m)
	area of pool (m^2)
SIZE1	pool area for EITA=1 condition (m^2)

Table 2. (continued)

STEADY	true if only steady-state calculation to be made
STOICH	true if pool fire and EITA=1
TAMB	ambient temperature (K)
TGAS	gas temperature (K)
TGAS1	previous value of TGAS (K)
TGAS2	previous value of TGAS1 (K)
TGASC	gas temperature (C)
TGASN	closest gas temperature, lower than true (K)
TGASP	closest gas temperature, higher than true (K)
TGOLD	value of TGAS from prior time step (K)
THICKW	wall thickness (m)
TINPT	input trial starting gas temperature (K)
TITLE	title of this run
TSF	wall surface temperature, fire side (K)
TSU	wall surface temperature, unexposed side (K)
TTIME	total time (s)
T1	old wall temperature profile (K)
T2	new wall temperature profile (K)
T2C	wall temperature profile (C)
VAVGIN	average inflow velocity (m/s)
VTSPEC	true if ventilation is fixed and pyrolysis rate pessimized
W	moles of water in fuel (mole/kg fuel)
WA	format constant
WB	format constant
WFLPC	percent of water, by weight, in fuel
WTFUEL	initial total mass of fuel (kg)
YCO2	mass fraction of CO_2 in outflow
YH20	mass fraction of H_2O in outflow
YN2	mass fraction of N_2 in outflow
YO2	mass fraction of O_2 in outflow
YPYR	mass fraction of pyrolysates in outflow

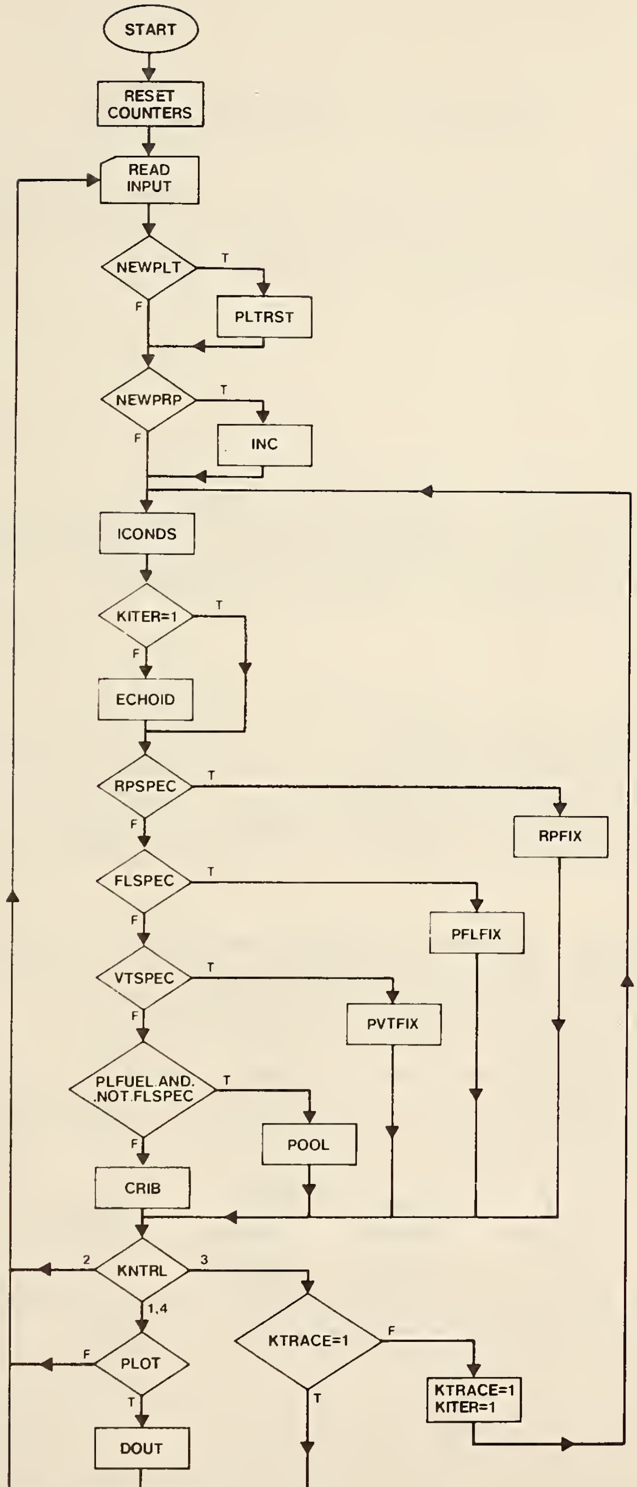

Figure 1. Flow chart for main program COMPF2

APPENDIX A -- SAMPLE PROBLEMS

Given below is a set of ten concatenated input problems. Each problem is intended to test out a subroutine or other feature of the program. The output for the problems is given following the input.

```
TEST PROGRAM FOR POOL FIRE, STEADY STATE, EITA=1.0
 $VARS AFLOOR=20.,AWALL=80.,AWDOW=4.,BPF=0.7,CD=0.68,CFLPC=85.7,
   CVGROS=46.5E6,DENSW=790.,DHP=2.4E6,EITA=1.0,FLOAD=20.,HFLPC=14.3,
   HWDOW=1.5,OFLPC=0.0,PLFUEL=T,STOICH=T,TBOILC=390.,
   THICKW=0.038,WFLPC=0.0$
001000001
          0.17
          0.5
TEST PROGRAM FOR POOL FIRE, STEADY STATE, EITA=0.01
 $VARS EISCAN=T,EITA=0.01,PLFUEL=T$
TEST PROGRAM WITH DELIBERATE ERROR TO CHECK KTRACE OPERATION
 $VARS EISCAN=T,PLFUEL=T,TBOILC=2000.$
TEST PROGRAM FOR POOL FIRE, TRANSIENT CASE, SIZE=7.5 M2
 $VARS DTIME=60.,MTIME=3600.,NEWPRP=T, PLFUEL=T, PRNT=60.,SIZE=7.5,
   TBOILC=390.$
000001
          840.
TEST PROGRAM FOR WOOD CRIB FIRE, REGRES SPECIFIED
 $VARS CFLPC=44.4,CVGROS=18.8E6,FLOAD=10.0,HFLPC=5.4,OFLPC=38.2,
   REGRES=1.5E-5,SHAPE=2.0,SIZE=0.05,WFLPC=12.0$
TEST PROGRAM 1 FOR WOOD CRIB FIRE, NILSSON'S FORMULAS
 $VARS REGRES=0.0,SH=0.10$
TEST PROGRAM 2 FOR WOOD CRIB FIRE, NILSSON'S FORMULAS
 $VARS FLOAD=20.,SH=0.20$
TEST PROGRAM FOR PVTFIX ROUTINE, VARIABLE WALL PROPERTIES
 $VARS NEWPRP=T,VTSPEC=T$
004008
273.      0.21      372.      0.21      373.      0.16      1073.     0.26
273.      1090.     372.      1090.     373.      47300.    383.      47300.
384.      5000.     413.      5000.     414.      840.      1073.     840.
TEST PROGRAM FOR PFLFIX ROUTINE, POOL OPTION
 $VARS AWDOW=10.,CFLPC=85.7,CVGROS=46.5E6,FLSPEC=T,HFLPC=14.3,NEWPRP=T,
   OFLPC=0.0,PLFUEL=T,SIZE=5.0,WFLPC=0.0$
001001
          0.17
          840.
TEST PROGRAM FOR RPFIX ROUTINE
 $VARS MTIME=1903.,NEWPRP=T,RPSPEC=T$
000000000003
0.0       0.12      120.      0.12      121.      0.25
```

```
TEST PROGRAM FOR POOL FIRE. STEADY STATE. EITA=1.0                              COMPF2 VERSION 1.1 - RUN NO.    1

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =     20.00 M2
WINDOW HEIGHT =       1.50 M
        AREA =       4.00 M2
OPENING FACTOR =    4.899 M2.5
DISCHARGE COEFF.=   .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2
TOTAL ENTHALPY OF PYROLYSIS=     2.40+06 J/KG
BOILING TEMPERATURE= 390. DEG C

FUEL COMPOSITION
CARBON   = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN   =    .0 PERCENT
NITROGEN =    .0 PERCENT
WATER    =    .0 PERCENT
R = 14.78
RO=  3.43
HEAT OF COMBUSTION OF DRY FUEL =    46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =    43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =     .170 W/M-K

EMISSIVITY =  .50

             THERMOPLASTIC POOL FIRE                                                    PAGE NO.  1    RUN NO.   1


        TIME   TEMP          WALL TEMPS        RP      RC    EXC.PYR.   FUEL    AIR IN      N.P.    VELOCITY   MOL.WT    FUEL
         S     GAS.C             C            KG/S    KG/S     KG/S      PCT     KG/S                  M/S               CNTRL

   1      0.   1169.     1157.  709.  262.    .153    .107      .046    100.0     2.26        .36       1.93      29.93     F

STOICHIOMETRIC FUEL SIZE=     1.741 M2


             THERMOPLASTIC POOL FIRE                                                    PAGE NO.  1    RUN NO.   1

  TIME                HEAT BALANCE                                           Q-WALL        YO2     YN2     YCO2    YH2O    YPYR
          GAS FLOW    WND RAD    WALL CNV   WALL RAD      Q-FIRE              SUM          PCT     PCT     PCT     PCT     PCT
            PCT         PCT         PCT        PCT          W                  J           MASS    MASS    MASS    MASS    MASS

    0.     69.955     21.096       .229      6.331      4.639+06          0.000         .063    .721    .139    .057    .019
```

TEST PROGRAM FOR POOL FIRE, STEADY STATE, EITA=0.01 COMPF2 VERSION 1.1 - RUN NO. 2

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA = 80.0 M2
FLOOR AREA = 20.00 M2
WINDOW HEIGHT = 1.50 M
AREA = 4.00 M2
OPENING FACTOR = 4.899 M2.5
DISCHARGE COEFF.= .68

----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA = 20.0 KG/M2
TOTAL ENTHALPY OF PYROLYSIS= 2.40+06 J/KG
BOILING TEMPERATURE= 390. DEG C

FUEL COMPOSITION
CARBON = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN = .0 PERCENT
NITROGEN = .0 PERCENT
WATER = .0 PERCENT
R = 14.78
RO= 3.43
HEAT OF COMBUSTION OF DRY FUEL = 46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION = 43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES = 28.97
CP OF PYROLYSIS GAS = (.1127*TGAS + 1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED = .70
GREY-GAS FLAME EMISSIVITY = .900
FUEL AREA= 174.07 M2

----WALL THERMAL PROPERTIES----

THICKNESS = .038 M
DENSITY = 790. KG/M3

THERMAL CONDUCTIVITY = .170 W/M-K

EMISSIVITY = .50

THERMOPLASTIC POOL FIRE PAGE NO. 1 RUN NO. 2

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	525.	501.	327.	153.	.785	.097	.688	100.0	2.04	.37	1.72	29.71	F

THERMOPLASTIC POOL FIRE PAGE NO. 1 RUN NO. 2

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	37.526	2.152	.608	2.218	4.188+06	0.000	.049	.555	.107	.044	.245

```
TEST PROGRAM WITH DELIBERATE ERROR TO CHECK KTRACE OPERATION                    COMPF2 VERSION 1.1 - RUN NO.   3

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =     20.00 M2
WINDOW HEIGHT =      1.50 M
        AREA =      4.00 M2
OPENING FACTOR =   4.899 M2.S
DISCHARGE COEFF.=  .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2
TOTAL ENTHALPY OF PYROLYSIS=     2.40+06 J/KG
BOILING TEMPERATURE=2000. DEG C

FUEL COMPOSITION
CARBON   = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN   =   .0 PERCENT
NITROGEN =   .0 PERCENT
WATER    =   .0 PERCENT
R = 14.78
R0=  3.43
HEAT OF COMBUSTION OF DRY FUEL =   46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =    43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900
FUEL AREA=     174.07 M2

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =    790. KG/M3

THERMAL CONDUCTIVITY =     .170 W/M-K

EMISSIVITY =  .50

            THERMOPLASTIC POOL FIRE                                                               PAGE NO.  1     RUN NO.   3


        TIME   TEMP          WALL TEMPS        RP      RC    EXC.PYR.   FUEL     AIR IN       N.P.     VELOCITY   MOL.WT   FUEL
         S     GAS.C             C            KG/S    KG/S     KG/S      PCT      KG/S                   M/S               CNTRL


---ITERATION FAILURE---
TGAS=          1890.00


TGAS.LT.TBOIL    TGAS=  1890.0    GO TO NEXT CASE


 RUN NO.    3
```

TGAS1	TGAS2	F1	F2	DERIV1	K	KD	KH	J	T2(I)	TSF	QFIRE	QFLOW	QRADW	RP	RC
1800.00	.00	2.43+08	0.00	1.35+05	1	3	0	1	1730.86	1791.43	4.028+05	-1.009+08	4.052+05	-59.938	.009
1810.00	1800.00	2.40+08	2.43+08	-2.93+05	2	3	0	1	1740.49	1801.51	2.891+04	-1.008+08	4.083+05	-59.068	.001
1900.00	1810.00	2.10+08	2.40+08	-3.33+05	3	3	0	1	1827.13	1892.16	2.405+03	-9.183+07	4.363+05	-50.558	.000

```
TEST PROGRAM FOR POOL FIRE, TRANSIENT CASE, SIZE=7.5 M2

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =    20.00 M2
WINDOW HEIGHT =      1.50 M
         AREA =      4.00 M2
OPENING FACTOR =   4.899 M2.5
DISCHARGE COEFF.=  .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2
TOTAL ENTHALPY OF PYROLYSIS=    2.40+06 J/KG
BOILING TEMPERATURE= 390. DEG C

FUEL COMPOSITION
CARBON   = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN   =   .0 PERCENT
NITROGEN =   .0 PERCENT
WATER    =   .0 PERCENT
R = 14.78
R0=  3.43
HEAT OF COMBUSTION OF DRY FUEL =   46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =   43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900
FUEL AREA=       7.50 M2

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =    .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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THERMOPLASTIC POOL FIRE PAGE NO. 1 RUN NO. 4

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	739.	513.	26.	25.	.306	.108	.198	95.4	2.29	.38	1.86	29.87	F
2	60.	826.	712.	34.	25.	.362	.106	.256	90.0	2.23	.37	1.87	29.85	F
3	120.	852.	763.	53.	25.	.381	.105	.277	84.3	2.21	.37	1.87	29.85	F
4	180.	870.	798.	83.	26.	.396	.104	.292	78.3	2.20	.37	1.87	29.84	F
5	240.	882.	820.	117.	27.	.406	.104	.302	72.2	2.19	.36	1.87	29.84	F
6	300.	891.	836.	151.	30.	.413	.103	.310	66.0	2.18	.36	1.87	29.83	F
7	360.	898.	847.	183.	34.	.419	.103	.316	59.7	2.18	.36	1.87	29.83	F
8	420.	903.	857.	213.	39.	.424	.103	.321	53.4	2.17	.36	1.87	29.83	F
9	480.	907.	864.	240.	46.	.428	.103	.325	47.0	2.17	.36	1.87	29.83	F
10	540.	911.	871.	265.	53.	.431	.103	.328	40.5	2.17	.36	1.87	29.83	F
11	600.	914.	876.	288.	61.	.434	.102	.331	34.0	2.16	.36	1.87	29.82	F
12	660.	917.	881.	309.	69.	.436	.102	.334	27.5	2.16	.36	1.87	29.82	F
13	720.	919.	885.	329.	77.	.439	.102	.336	20.9	2.16	.36	1.87	29.82	F
14	780.	921.	888.	347.	85.	.440	.102	.338	14.3	2.16	.36	1.87	29.82	F
15	840.	923.	892.	364.	93.	.442	.102	.340	7.6	2.16	.36	1.87	29.82	F
16	900.	925.	894.	380.	101.	.444	.102	.342	1.0	2.15	.36	1.87	29.82	F
17	960.	926.	897.	394.	108.	.445	.102	.343	.0	2.15	.36	1.87	29.82	F
18	1020.	358.	534.	407.	115.	.000	.000	.000	.0	2.47	.43	1.78	26.90	T
19	1080.	255.	409.	414.	122.	.000	.000	.000	.0	2.39	.45	1.66	26.95	T
20	1140.	211.	350.	412.	128.	.000	.000	.000	.0	2.32	.45	1.59	26.94	T
21	1200.	184.	310.	402.	133.	.000	.000	.000	.0	2.26	.46	1.54	26.90	T
22	1260.	164.	280.	387.	137.	.000	.000	.000	.0	2.21	.46	1.49	26.87	T
23	1320.	149.	257.	371.	141.	.000	.000	.000	.0	2.16	.46	1.45	26.84	T
24	1380.	138.	238.	355.	143.	.000	.000	.000	.0	2.12	.47	1.42	26.80	T
25	1440.	129.	222.	339.	145.	.000	.000	.000	.0	2.09	.47	1.39	26.78	T
26	1500.	121.	209.	324.	145.	.000	.000	.000	.0	2.05	.47	1.36	26.75	T
27	1560.	114.	198.	310.	145.	.000	.000	.000	.0	2.02	.47	1.34	26.73	T
28	1620.	108.	188.	296.	144.	.000	.000	.000	.0	1.99	.47	1.31	26.70	T
29	1680.	103.	179.	284.	142.	.000	.000	.000	.0	1.97	.47	1.30	26.67	T
30	1740.	99.	171.	272.	140.	.000	.000	.000	.0	1.95	.47	1.28	26.64	T
31	1800.	95.	164.	261.	137.	.000	.000	.000	.0	1.92	.48	1.26	26.62	T
32	1860.	91.	157.	251.	135.	.000	.000	.000	.0	1.90	.48	1.24	26.60	T
33	1920.	88.	151.	241.	132.	.000	.000	.000	.0	1.88	.48	1.23	26.58	T
34	1980.	85.	146.	232.	129.	.000	.000	.000	.0	1.86	.48	1.22	26.56	T
35	2040.	82.	141.	223.	126.	.000	.000	.000	.0	1.85	.48	1.20	26.54	T
36	2100.	80.	136.	215.	123.	.000	.000	.000	.0	1.83	.48	1.19	26.52	T

THERMOPLASTIC POOL FIRE PAGE NO. 1 RUN NO. 4

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	44.886	5.022	11.092	28.910	4.694+06	1.127+08	.060	.679	.131	.054	.076
60.	51.859	7.174	4.559	22.952	4.582+06	1.883+08	.058	.663	.128	.052	.099
120.	54.089	7.950	3.297	20.091	4.543+06	2.520+08	.058	.657	.127	.052	.107
180.	55.726	8.546	2.523	17.707	4.514+06	3.068+08	.057	.652	.126	.052	.113
240.	56.787	8.943	2.091	16.097	4.496+06	3.559+08	.057	.650	.126	.051	.116
300.	57.586	9.250	1.787	14.794	4.481+06	4.005+08	.057	.647	.125	.051	.119
360.	58.196	9.486	1.574	13.785	4.470+06	4.417+08	.057	.646	.125	.051	.122
420.	58.693	9.681	1.411	12.954	4.461+06	4.801+08	.057	.644	.125	.051	.124
480.	59.095	9.840	1.283	12.252	4.453+06	5.163+08	.056	.643	.124	.051	.125
540.	59.440	9.978	1.180	11.659	4.447+06	5.505+08	.056	.642	.124	.051	.126
600.	59.737	10.097	1.094	11.144	4.442+06	5.832+08	.056	.641	.124	.051	.128
660.	59.996	10.201	1.022	10.691	4.437+06	6.143+08	.056	.641	.124	.051	.129
720.	60.224	10.294	.960	10.290	4.433+06	6.443+08	.056	.640	.124	.051	.130
780.	60.427	10.376	.907	9.929	4.429+06	6.731+08	.056	.639	.124	.051	.130
840.	60.610	10.451	.860	9.604	4.426+06	7.008+08	.056	.639	.123	.051	.131
900.	60.776	10.518	.818	9.308	4.423+06	7.277+08	.056	.638	.123	.051	.132
960.	60.927	10.580	.781	9.037	4.420+06	7.537+08	.056	.638	.123	.050	.132
1020.	96.257	3.743	-40.770	-59.079	0.000	7.537+08	.230	.770	.000	.000	.000
1080.	97.357	2.643	-52.654	-47.486	0.000	7.537+08	.230	.770	.000	.000	.000
1140.	97.717	2.283	-58.391	-41.795	0.000	7.537+08	.230	.770	.000	.000	.000
1200.	97.914	2.086	-62.064	-37.859	0.000	7.537+08	.230	.770	.000	.000	.000
1260.	98.036	1.964	-64.780	-35.129	0.000	7.537+08	.230	.770	.000	.000	.000
1320.	98.120	1.880	-67.042	-33.129	0.000	7.537+08	.230	.770	.000	.000	.000
1380.	98.180	1.820	-68.677	-31.505	0.000	7.537+08	.230	.770	.000	.000	.000
1440.	98.223	1.777	-69.805	-30.128	0.000	7.537+08	.230	.770	.000	.000	.000
1500.	98.258	1.742	-71.093	-29.103	0.000	7.537+08	.230	.770	.000	.000	.000
1560.	98.285	1.715	-71.919	-28.159	0.000	7.537+08	.230	.770	.000	.000	.000
1620.	98.306	1.694	-72.779	-27.407	0.000	7.537+08	.230	.770	.000	.000	.000
1680.	98.324	1.676	-73.334	-26.712	0.000	7.537+08	.230	.770	.000	.000	.000
1740.	98.338	1.662	-73.959	-26.146	0.000	7.537+08	.230	.770	.000	.000	.000
1800.	98.349	1.651	-74.362	-25.603	0.000	7.537+08	.230	.770	.000	.000	.000
1860.	98.359	1.641	-74.862	-25.162	0.000	7.537+08	.230	.770	.000	.000	.000
1920.	98.367	1.633	-75.260	-24.756	0.000	7.537+08	.230	.770	.000	.000	.000
1980.	98.374	1.626	-75.620	-24.394	0.000	7.537+08	.230	.770	.000	.000	.000
2040.	98.379	1.621	-75.777	-24.028	0.000	7.537+08	.230	.770	.000	.000	.000
2100.	98.384	1.616	-76.079	-23.735	0.000	7.537+08	.230	.770	.000	.000	.000

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TEST PROGRAM FOR WOOD CRIB FIRE, REGRES SPECIFIED

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =    20.00 M2
WINDOW HEIGHT =      1.50 M
         AREA =      4.00 M2
OPENING FACTOR =    4.899 M2.5
DISCHARGE COEFF.=   .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  10.0 KG/M2

FUEL COMPOSITION
CARBON    = 44.4 PERCENT BY WEIGHT
HYDROGEN =  5.4 PERCENT
OXYGEN    = 38.2 PERCENT
NITROGEN =   .0 PERCENT
WATER     = 12.0 PERCENT
R =  5.32
RO=  1.23
HEAT OF COMBUSTION OF DRY FUEL =    18.80+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =    15.07+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900
RATE OF REGRESSION =  15.00-06 M/S
FUEL DIMENSION =  .050 M
SHAPE FACTOR = 2.00


----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =    .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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CRIB FIRE PAGE NO. 1 RUN NO. 5

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	510.	296.	26.	25.	.240	.168	.072	92.8	2.35	.41	1.80	29.90	T
2	60.	560.	422.	30.	25.	.231	.162	.069	85.9	2.35	.40	1.82	29.86	T
3	120.	572.	461.	41.	25.	.222	.156	.067	79.2	2.36	.40	1.83	29.83	T
4	180.	574.	482.	58.	25.	.214	.150	.064	72.8	2.36	.40	1.83	29.79	T
5	240.	571.	490.	78.	26.	.205	.143	.061	66.6	2.37	.40	1.83	29.76	T
6	300.	563.	492.	98.	28.	.196	.137	.059	60.8	2.37	.40	1.83	29.72	T
7	360.	553.	489.	117.	30.	.187	.131	.056	55.2	2.38	.41	1.83	29.69	T
8	420.	540.	483.	134.	33.	.178	.125	.053	49.8	2.38	.41	1.82	29.65	T
9	480.	526.	474.	149.	37.	.169	.119	.051	44.7	2.39	.41	1.82	29.62	T
10	540.	510.	463.	162.	42.	.161	.112	.048	39.9	2.39	.41	1.81	29.58	T
11	600.	494.	451.	174.	46.	.152	.106	.045	35.4	2.40	.41	1.81	29.55	T
12	660.	476.	437.	184.	51.	.143	.100	.043	31.1	2.40	.42	1.80	29.51	T
13	720.	457.	423.	192.	56.	.134	.094	.040	27.1	2.40	.42	1.79	29.48	T
14	780.	438.	408.	199.	61.	.125	.087	.037	23.3	2.40	.42	1.78	29.44	T
15	840.	417.	392.	204.	66.	.116	.081	.035	19.8	2.40	.42	1.76	29.41	T
16	900.	396.	375.	209.	70.	.107	.075	.032	16.6	2.40	.43	1.75	29.37	T
17	960.	374.	358.	212.	74.	.098	.069	.029	13.7	2.39	.43	1.73	29.33	T
18	1020.	352.	341.	214.	78.	.089	.062	.027	11.0	2.38	.43	1.71	29.30	T
19	1080.	328.	324.	216.	81.	.080	.056	.024	8.6	2.37	.44	1.69	29.26	T
20	1140.	304.	307.	216.	84.	.071	.049	.021	6.5	2.35	.44	1.66	29.23	T
21	1200.	279.	289.	216.	87.	.061	.043	.018	4.7	2.33	.45	1.63	29.19	T
22	1260.	253.	271.	214.	89.	.052	.036	.016	3.1	2.29	.45	1.59	29.15	T
23	1320.	226.	252.	213.	91.	.042	.030	.013	1.9	2.25	.45	1.54	29.12	T
24	1380.	199.	233.	210.	93.	.033	.023	.010	.9	2.19	.46	1.48	29.08	T
25	1440.	169.	213.	207.	94.	.022	.016	.007	.2	2.10	.47	1.40	29.03	T
26	1500.	134.	190.	203.	95.	.011	.008	.003	.0	1.96	.47	1.29	28.98	T
27	1560.	100.	166.	198.	96.	.000	.000	.000	.0	1.74	.48	1.13	28.92	T
28	1620.	92.	152.	193.	96.	.000	.000	.000	.0	1.68	.48	1.08	28.92	T
29	1680.	87.	143.	187.	96.	.000	.000	.000	.0	1.63	.48	1.05	28.92	T
30	1740.	83.	135.	181.	96.	.000	.000	.000	.0	1.59	.49	1.02	28.92	T
31	1800.	79.	129.	175.	95.	.000	.000	.000	.0	1.55	.49	.99	28.92	T

CRIB FIRE PAGE NO. 1 RUN NO. 5

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	55.544	3.303	19.249	21.906	2.531+06	6.250+07	.129	.699	.106	.043	.028
60.	63.693	4.410	11.122	20.800	2.438+06	1.092+08	.132	.701	.102	.041	.027
120.	67.496	4.843	8.615	19.040	2.345+06	1.481+08	.136	.704	.098	.040	.026
180.	70.479	5.113	7.081	17.334	2.252+06	1.811+08	.139	.706	.094	.038	.025
240.	72.815	5.238	6.119	15.828	2.159+06	2.095+08	.143	.709	.091	.037	.024
300.	74.815	5.278	5.434	14.473	2.066+06	2.342+08	.147	.711	.087	.035	.023
360.	76.584	5.253	4.919	13.244	1.973+06	2.557+08	.150	.714	.083	.034	.022
420.	78.203	5.181	4.507	12.109	1.880+06	2.745+08	.154	.716	.079	.032	.021
480.	79.721	5.074	4.160	11.046	1.786+06	2.908+08	.158	.719	.075	.030	.020
540.	81.173	4.941	3.852	10.036	1.693+06	3.049+08	.161	.722	.072	.029	.019
600.	82.590	4.787	3.564	9.062	1.599+06	3.170+08	.165	.724	.068	.027	.018
660.	83.993	4.619	3.280	8.112	1.505+06	3.273+08	.169	.727	.064	.026	.017
720.	85.405	4.440	2.987	7.173	1.411+06	3.359+08	.172	.729	.060	.024	.016
780.	86.848	4.254	2.673	6.232	1.317+06	3.429+08	.176	.732	.056	.023	.015
840.	88.347	4.064	2.324	5.281	1.222+06	3.485+08	.180	.735	.052	.021	.014
900.	89.926	3.872	1.924	4.299	1.127+06	3.527+08	.183	.737	.049	.020	.013
960.	91.618	3.681	1.461	3.268	1.032+06	3.556+08	.187	.740	.045	.018	.012
1020.	93.446	3.492	.919	2.150	9.368+05	3.573+08	.191	.742	.041	.017	.011
1080.	95.478	3.308	.318	.902	8.407+05	3.580+08	.194	.745	.037	.015	.010
1140.	96.899	3.101	-.220	-.632	7.440+05	3.580+08	.198	.748	.033	.013	.009
1200.	97.133	2.867	-1.288	-2.188	6.465+05	3.580+08	.202	.750	.029	.012	.008
1260.	97.353	2.647	-3.035	-3.814	5.479+05	3.580+08	.206	.753	.025	.010	.007
1320.	97.559	2.441	-5.736	-5.614	4.476+05	3.580+08	.210	.756	.021	.009	.006
1380.	97.750	2.250	-10.041	-7.776	3.446+05	3.580+08	.214	.759	.017	.007	.004
1440.	97.922	2.078	-17.571	-10.734	2.366+05	3.580+08	.218	.762	.012	.005	.003
1500.	98.072	1.928	-34.791	-16.210	1.134+05	3.580+08	.224	.766	.006	.003	.002
1560.	98.139	1.861	-73.760	-26.340	0.000	3.580+08	.230	.770	.000	.000	.000
1620.	98.135	1.865	-74.639	-25.412	0.000	3.580+08	.230	.770	.000	.000	.000
1680.	98.127	1.873	-75.239	-24.810	0.000	3.580+08	.230	.770	.000	.000	.000
1740.	98.116	1.884	-75.698	-24.354	0.000	3.580+08	.230	.770	.000	.000	.000
1800.	98.104	1.896	-76.063	-23.994	0.000	3.580+08	.230	.770	.000	.000	.000

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TEST PROGRAM 1 FOR WOOD CRIB FIRE, NILSSON'S FORMULAS

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =     20.00 M2
WINDOW HEIGHT =      1.50 M
         AREA =      4.00 M2
OPENING FACTOR =    4.899 M2.5
DISCHARGE COEFF.=   .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  10.0 KG/M2

FUEL COMPOSITION
CARBON    = 44.4 PERCENT BY WEIGHT
HYDROGEN =  5.4 PERCENT
OXYGEN    = 38.2 PERCENT
NITROGEN =   .0 PERCENT
WATER     = 12.0 PERCENT
R =  5.32
RO=  1.23
HEAT OF COMBUSTION OF DRY FUEL =   18.80+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =   15.07+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900
RATE OF REGRESSION =  00.00    M/S
FUEL DIMENSION =  .050 M
SHAPE FACTOR = 2.00

CRIB SPACING/HEIGHT RATIO=  .100

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =    .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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CRIB FIRE PAGE NO. 1 RUN NO. 6

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	408.	217.	25.	25.	.176	.123	.053	94.7	2.36	.42	1.74	29.65	T
2	60.	452.	315.	28.	25.	.176	.123	.053	89.4	2.38	.42	1.78	29.65	T
3	120.	472.	357.	36.	25.	.176	.123	.053	84.2	2.38	.41	1.79	29.65	T
4	180.	487.	386.	49.	25.	.176	.123	.053	78.9	2.38	.41	1.80	29.65	T
5	240.	498.	408.	64.	26.	.176	.123	.053	73.6	2.38	.41	1.80	29.65	T
6	300.	506.	424.	80.	27.	.176	.123	.053	68.3	2.38	.41	1.81	29.65	T
7	360.	513.	438.	96.	29.	.176	.123	.053	63.0	2.38	.41	1.81	29.65	T
8	420.	519.	449.	111.	31.	.176	.123	.053	57.8	2.39	.41	1.81	29.65	T
9	480.	524.	458.	126.	34.	.176	.123	.053	52.5	2.39	.41	1.82	29.65	T
10	540.	524.	463.	139.	38.	.173	.121	.052	47.3	2.39	.41	1.82	29.64	T
11	600.	512.	458.	152.	42.	.165	.115	.049	42.3	2.39	.41	1.81	29.60	T
12	660.	497.	449.	164.	46.	.156	.109	.047	37.7	2.40	.41	1.81	29.56	T
13	720.	481.	438.	174.	51.	.147	.103	.044	33.3	2.40	.42	1.80	29.53	T
14	780.	464.	425.	183.	55.	.138	.097	.041	29.1	2.40	.42	1.79	29.49	T
15	840.	445.	411.	191.	60.	.129	.090	.039	25.2	2.40	.42	1.78	29.46	T
16	900.	425.	396.	198.	64.	.120	.084	.036	21.6	2.40	.42	1.77	29.42	T
17	960.	405.	381.	203.	68.	.111	.078	.033	18.3	2.40	.43	1.76	29.39	T
18	1020.	384.	364.	207.	72.	.102	.072	.031	15.2	2.39	.43	1.74	29.35	T
19	1080.	362.	348.	210.	76.	.093	.065	.028	12.4	2.39	.43	1.72	29.32	T
20	1140.	339.	330.	212.	79.	.084	.059	.025	9.9	2.38	.44	1.70	29.28	T
21	1200.	315.	313.	213.	82.	.075	.053	.023	7.6	2.36	.44	1.67	29.25	T
22	1260.	291.	296.	213.	85.	.066	.046	.020	5.6	2.34	.44	1.64	29.21	T
23	1320.	266.	279.	213.	87.	.057	.040	.017	3.9	2.31	.45	1.61	29.17	T
24	1380.	240.	261.	211.	90.	.047	.033	.014	2.5	2.27	.45	1.57	29.14	T
25	1440.	213.	242.	209.	91.	.038	.027	.011	1.4	2.22	.46	1.51	29.10	T
26	1500.	185.	222.	206.	93.	.028	.020	.008	.5	2.15	.46	1.45	29.06	T
27	1560.	154.	201.	203.	94.	.017	.012	.005	.0	2.04	.47	1.36	29.01	T
28	1620.	109.	175.	199.	94.	.002	.001	.001	.0	1.80	.48	1.17	28.93	T
29	1680.	95.	157.	194.	95.	.000	.000	.000	.0	1.70	.48	1.10	28.92	T
30	1740.	89.	146.	189.	95.	.000	.000	.000	.0	1.65	.48	1.06	28.92	T
31	1800.	84.	138.	183.	95.	.000	.000	.000	.0	1.60	.48	1.03	28.92	T
32	1860.	81.	131.	177.	95.	.000	.000	.000	.0	1.56	.49	1.00	28.92	T
33	1920.	77.	125.	171.	94.	.000	.000	.000	.0	1.53	.49	.98	28.92	T

CRIB FIRE PAGE NO. 1 RUN NO. 6

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	57.683	2.530	22.491	17.294	1.856+06	4.431+07	.154	.717	.079	.032	.021
60.	64.928	3.282	14.508	17.280	1.856+06	7.971+07	.155	.717	.079	.032	.021
120.	68.196	3.673	11.511	16.622	1.856+06	1.110+08	.155	.717	.078	.032	.021
180.	70.573	3.978	9.568	15.881	1.856+06	1.394+08	.155	.717	.078	.032	.021
240.	72.319	4.215	8.266	15.200	1.856+06	1.655+08	.155	.717	.078	.032	.021
300.	73.706	4.411	7.306	14.578	1.856+06	1.899+08	.155	.717	.078	.032	.021
360.	74.838	4.576	6.571	14.020	1.856+06	2.128+08	.155	.717	.078	.032	.021
420.	75.787	4.717	5.985	13.515	1.856+06	2.345+08	.155	.717	.078	.032	.021
480.	76.597	4.841	5.508	13.059	1.856+06	2.552+08	.155	.717	.078	.032	.021
540.	77.663	4.912	5.042	12.382	1.829+06	2.743+08	.156	.718	.077	.031	.020
600.	79.542	4.862	4.485	11.111	1.736+06	2.906+08	.160	.720	.073	.030	.019
660.	81.169	4.755	4.077	10.001	1.643+06	3.045+08	.163	.723	.070	.028	.018
720.	82.701	4.618	3.722	8.962	1.550+06	3.162+08	.167	.726	.066	.027	.017
780.	84.190	4.461	3.388	7.965	1.456+06	3.262+08	.171	.728	.062	.025	.016
840.	85.673	4.291	3.052	6.989	1.362+06	3.344+08	.174	.731	.058	.023	.015
900.	87.180	4.113	2.697	6.017	1.268+06	3.410+08	.178	.733	.054	.022	.014
960.	88.743	3.930	2.307	5.036	1.174+06	3.462+08	.181	.736	.051	.020	.013
1020.	90.393	3.745	1.864	4.022	1.080+06	3.500+08	.185	.738	.047	.019	.012
1080.	92.159	3.560	1.351	2.951	9.850+05	3.525+08	.189	.741	.043	.017	.011
1140.	94.085	3.378	.759	1.783	8.897+05	3.539+08	.193	.744	.039	.016	.010
1200.	96.227	3.200	.135	.453	7.938+05	3.542+08	.196	.746	.035	.014	.009
1260.	97.021	2.979	-.524	-1.158	6.973+05	3.542+08	.200	.749	.031	.013	.008
1320.	97.247	2.753	-1.857	-2.747	5.998+05	3.542+08	.204	.752	.027	.011	.007
1380.	97.458	2.542	-3.970	-4.448	5.009+05	3.542+08	.208	.754	.023	.009	.006
1440.	97.655	2.345	-7.264	-6.383	4.001+05	3.542+08	.212	.757	.019	.008	.005
1500.	97.836	2.164	-12.695	-8.823	2.958+05	3.542+08	.216	.760	.015	.006	.004
1560.	97.997	2.003	-23.094	-12.532	1.840+05	3.542+08	.221	.763	.010	.004	.003
1620.	98.133	1.867	-62.659	-23.888	2.191+04	3.542+08	.229	.769	.001	.001	.000
1680.	98.137	1.863	-74.329	-25.735	0.000	3.542+08	.230	.770	.000	.000	.000
1740.	98.130	1.870	-75.024	-25.025	0.000	3.542+08	.230	.770	.000	.000	.000
1800.	98.120	1.880	-75.537	-24.512	0.000	3.542+08	.230	.770	.000	.000	.000
1860.	98.108	1.892	-75.938	-24.116	0.000	3.542+08	.230	.770	.000	.000	.000
1920.	98.095	1.905	-76.262	-23.798	0.000	3.542+08	.230	.770	.000	.000	.000

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TEST PROGRAM 2 FOR WOOD CRIB FIRE, NILSSON'S FORMULAS

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =    20.00 M2
WINDOW HEIGHT =      1.50 M
        AREA =      4.00 M2
OPENING FACTOR =   4.899 M2.5
DISCHARGE COEFF.=  .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2

FUEL COMPOSITION
CARBON    = 44.4 PERCENT BY WEIGHT
HYDROGEN =  5.4 PERCENT
OXYGEN    = 38.2 PERCENT
NITROGEN =   .0 PERCENT
WATER     = 12.0 PERCENT
R =  5.32
RO=  1.23
HEAT OF COMBUSTION OF DRY FUEL =   18.80+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =   15.07+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =   .70
GREY-GAS FLAME EMISSIVITY =  .900
RATE OF REGRESSION =  00.00    M/S
FUEL DIMENSION =  .050 M
SHAPE FACTOR = 2.00

CRIB SPACING/HEIGHT RATIO=  .200

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =    .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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CR18 FIRE PAGE NO. 1 RUN NO. 7

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	739.	514.	26.	25.	.479	.288	.191	92.8	2.19	.37	1.83	30.60	F
2	60.	858.	745.	34.	25.	.461	.286	.176	85.9	2.17	.36	1.85	30.60	F
3	120.	902.	815.	54.	25.	.444	.286	.158	79.2	2.17	.36	1.86	30.60	F
4	180.	936.	866.	85.	26.	.426	.286	.141	72.8	2.17	.36	1.87	30.59	F
5	240.	960.	900.	122.	27.	.409	.286	.123	66.7	2.17	.36	1.87	30.59	T
6	300.	955.	905.	159.	30.	.391	.274	.117	60.8	2.18	.36	1.88	30.52	T
7	360.	942.	897.	194.	34.	.374	.261	.112	55.2	2.20	.36	1.88	30.45	T
8	420.	924.	884.	227.	40.	.356	.249	.107	49.9	2.21	.37	1.88	30.38	T
9	480.	903.	866.	255.	47.	.338	.237	.101	44.8	2.23	.37	1.88	30.31	T
10	540.	879.	846.	281.	55.	.321	.224	.096	40.0	2.25	.37	1.88	30.24	T
11	600.	853.	822.	302.	63.	.303	.212	.091	35.5	2.26	.37	1.88	30.17	T
12	660.	824.	797.	321.	72.	.285	.200	.086	31.2	2.28	.38	1.88	30.09	T
13	720.	794.	769.	336.	80.	.267	.187	.080	27.2	2.30	.38	1.88	30.02	T
14	780.	762.	740.	349.	89.	.250	.175	.075	23.4	2.31	.38	1.88	29.95	T
15	840.	728.	709.	360.	97.	.232	.162	.070	20.0	2.33	.39	1.87	29.87	T
16	900.	693.	678.	368.	104.	.214	.150	.064	16.8	2.35	.39	1.87	29.80	T
17	960.	656.	644.	374.	111.	.196	.137	.059	13.8	2.37	.40	1.86	29.73	T
18	1020.	617.	610.	378.	117.	.178	.125	.053	11.1	2.38	.40	1.85	29.65	T
19	1080.	576.	575.	380.	122.	.160	.112	.048	8.7	2.39	.40	1.84	29.58	T
20	1140.	533.	540.	380.	127.	.142	.099	.042	6.6	2.41	.41	1.83	29.51	T
21	1200.	489.	504.	379.	131.	.123	.086	.037	4.8	2.41	.42	1.81	29.43	T
22	1260.	442.	467.	376.	134.	.105	.073	.031	3.2	2.42	.42	1.78	29.36	T
23	1320.	393.	429.	372.	137.	.086	.060	.026	1.9	2.41	.43	1.75	29.28	T
24	1380.	342.	390.	366.	139.	.066	.046	.020	.9	2.39	.44	1.71	29.21	T
25	1440.	286.	350.	359.	141.	.046	.032	.014	.2	2.35	.44	1.64	29.12	T
26	1500.	223.	307.	350.	142.	.023	.016	.007	.0	2.25	.46	1.54	29.03	T
27	1560.	155.	261.	341.	143.	.000	.000	.000	.0	2.06	.47	1.37	28.92	T
28	1620.	140.	236.	330.	143.	.000	.000	.000	.0	1.99	.47	1.31	28.92	T
29	1680.	129.	219.	318.	143.	.000	.000	.000	.0	1.94	.47	1.27	28.92	T
30	1740.	121.	205.	306.	142.	.000	.000	.000	.0	1.89	.48	1.24	28.92	T
31	1800.	115.	194.	294.	141.	.000	.000	.000	.0	1.85	.48	1.21	28.92	T
32	1860.	109.	184.	282.	139.	.000	.000	.000	.0	1.81	.48	1.18	28.92	T
33	1920.	105.	175.	270.	137.	.000	.000	.000	.0	1.78	.48	1.15	28.92	T
34	1980.	101.	168.	260.	135.	.000	.000	.000	.0	1.75	.48	1.13	28.92	T
35	2040.	97.	161.	250.	133.	.000	.000	.000	.0	1.72	.48	1.11	28.92	T
36	2100.	94.	155.	240.	130.	.000	.000	.000	.0	1.69	.48	1.09	28.92	T
37	2160.	91.	149.	231.	128.	.000	.000	.000	.0	1.66	.48	1.07	28.92	T
38	2220.	88.	144.	223.	125.	.000	.000	.000	.0	1.64	.48	1.05	28.92	T
39	2280.	85.	139.	214.	122.	.000	.000	.000	.0	1.61	.48	1.04	28.92	T
40	2340.	83.	135.	207.	119.	.000	.000	.000	.0	1.59	.49	1.02	28.92	T
41	2400.	81.	131.	199.	117.	.000	.000	.000	.0	1.56	.49	1.00	28.92	T
42	2460.	79.	127.	192.	114.	.000	.000	.000	.0	1.54	.49	.99	28.92	T

CR18 FIRE PAGE NO. 1 RUN NO. 7

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	51.239	5.446	11.986	31.326	4.342+06	1.128+08	.055	.632	.176	.074	.071
60.	59.890	8.578	4.838	26.713	4.305+06	1.943+08	.056	.635	.177	.074	.067
120.	62.785	10.011	3.385	23.867	4.301+06	2.647+08	.056	.639	.178	.073	.061
180.	64.837	11.207	2.533	21.406	4.303+06	3.265+08	.057	.644	.179	.073	.054
240.	66.133	12.113	2.058	19.706	4.310+06	3.828+08	.057	.648	.180	.073	.047
300.	68.439	12.473	1.715	17.383	4.125+06	4.300+08	.064	.653	.173	.070	.046
360.	70.315	12.500	1.524	15.674	3.939+06	4.707+08	.071	.658	.166	.067	.044
420.	72.040	12.361	1.389	14.222	3.754+06	5.058+08	.078	.663	.158	.064	.042
480.	73.682	12.102	1.287	12.939	3.568+06	5.363+08	.086	.669	.150	.061	.040
540.	75.291	11.754	1.203	11.759	3.381+06	5.626+08	.093	.674	.142	.058	.037
600.	76.901	11.339	1.128	10.638	3.195+06	5.851+08	.101	.679	.135	.054	.035
660.	78.537	10.870	1.056	9.543	3.008+06	6.043+08	.108	.684	.127	.051	.033
720.	80.222	10.360	.978	8.444	2.821+06	6.202+08	.116	.690	.119	.048	.031
780.	81.979	9.818	.888	7.317	2.633+06	6.332+08	.123	.695	.111	.045	.029
840.	83.833	9.251	.778	6.136	2.445+06	6.433+08	.131	.700	.103	.042	.027
900.	85.814	8.668	.640	4.874	2.256+06	6.508+08	.139	.706	.095	.038	.025
960.	87.960	8.074	.464	3.496	2.067+06	6.557+08	.146	.711	.087	.035	.023
1020.	90.318	7.476	.243	1.956	1.877+06	6.582+08	.154	.716	.079	.032	.021
1080.	92.946	6.878	.010	.165	1.686+06	6.583+08	.162	.722	.071	.029	.019
1140.	93.846	6.154	-.314	-1.899	1.494+06	6.583+08	.169	.727	.063	.026	.017
1200.	94.558	5.442	-1.020	-4.049	1.300+06	6.583+08	.177	.733	.055	.022	.015
1260.	95.238	4.762	-2.239	-6.376	1.103+06	6.583+08	.185	.738	.047	.019	.012
1320.	95.883	4.117	-4.264	-8.925	9.040+05	6.583+08	.192	.744	.039	.016	.010
1380.	96.485	3.515	-7.700	-11.864	6.995+05	6.583+08	.200	.749	.031	.012	.008
1440.	97.049	2.951	-14.093	-15.688	4.853+05	6.583+08	.209	.755	.022	.009	.006
1500.	97.574	2.426	-28.573	-21.936	2.439+05	6.583+08	.219	.762	.012	.005	.003
1560.	97.982	2.018	-66.264	-33.909	0.000	6.583+08	.230	.770	.000	.000	.000
1620.	98.049	1.951	-68.413	-31.701	0.000	6.583+08	.230	.770	.000	.000	.000
1680.	98.085	1.915	-69.814	-30.274	0.000	6.583+08	.230	.770	.000	.000	.000
1740.	98.107	1.893	-70.898	-29.183	0.000	6.583+08	.230	.770	.000	.000	.000
1800.	98.122	1.878	-71.769	-28.312	0.000	6.583+08	.230	.770	.000	.000	.000
1860.	98.131	1.869	-72.495	-27.590	0.000	6.583+08	.230	.770	.000	.000	.000
1920.	98.136	1.864	-73.116	-26.981	0.000	6.583+08	.230	.770	.000	.000	.000
1980.	98.138	1.862	-73.665	-26.462	0.000	6.583+08	.230	.770	.000	.000	.000
2040.	98.138	1.862	-73.953	-25.954	0.000	6.583+08	.230	.770	.000	.000	.000
2100.	98.136	1.864	-74.573	-25.606	0.000	6.583+08	.230	.770	.000	.000	.000
2160.	98.133	1.867	-74.768	-25.201	0.000	6.583+08	.230	.770	.000	.000	.000
2220.	98.128	1.872	-75.114	-24.888	0.000	6.583+08	.230	.770	.000	.000	.000
2280.	98.123	1.877	-75.413	-24.604	0.000	6.583+08	.230	.770	.000	.000	.000
2340.	98.116	1.884	-75.679	-24.347	0.000	6.583+08	.230	.770	.000	.000	.000
2400.	98.109	1.891	-75.769	-24.079	0.000	6.583+08	.230	.770	.000	.000	.000
2460.	98.100	1.900	-75.979	-23.867	0.000	6.583+08	.230	.770	.000	.000	.000

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TEST PROGRAM FOR PVTFIX ROUTINE. VARIABLE WALL PROPERTIES

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =     20.00 M2
WINDOW HEIGHT =      1.50 M
          AREA =      4.00 M2
OPENING FACTOR =    4.899 M2.5
DISCHARGE COEFF.=   .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2

FUEL COMPOSITION
CARBON    = 44.4 PERCENT BY WEIGHT
HYDROGEN =  5.4 PERCENT
OXYGEN    = 38.2 PERCENT
NITROGEN =    .0 PERCENT
WATER     = 12.0 PERCENT
R =  5.32
R0=  1.23
HEAT OF COMBUSTION OF DRY FUEL =    18.80+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =    15.07+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY ARRAY (W/M-K)
TEMPERATURE   CONDUCTIVITY
    273.0          .210
    372.0          .210
    373.0          .160
   1073.0          .260


HEAT CAPACITY ARRAY (J/KG-K)
TEMPERATURE   HEAT CAPACITY
    273.0         1090.
    372.0         1090.
    373.0        47300.
    383.0        47300.
    384.0         5000.
    413.0         5000.
    414.0          840.
   1073.0          840.


EMISSIVITY =  .50
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VENTILATION SPECIFIED, FUEL PYROLYSIS ADJUSTED FOR WORST CONDITIONS PAGE NO. 1 RUN NO.

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	720.	453.	26.	25.	.419	.293	.126	93.7	2.23	.38	1.84	30.59	F
2	60.	853.	729.	32.	25.	.414	.290	.124	87.5	2.20	.37	1.86	30.59	F
3	120.	887.	787.	48.	25.	.412	.289	.124	81.3	2.19	.37	1.87	30.59	F
4	180.	913.	829.	75.	26.	.411	.288	.123	75.2	2.19	.36	1.87	30.59	F
5	240.	933.	860.	96.	27.	.410	.287	.123	69.0	2.18	.36	1.87	30.59	F
6	300.	947.	881.	131.	29.	.409	.287	.123	62.9	2.18	.36	1.87	30.59	F
7	360.	959.	898.	146.	32.	.409	.286	.123	56.7	2.17	.36	1.87	30.59	F
8	420.	969.	914.	214.	36.	.408	.286	.122	50.6	2.17	.36	1.88	30.59	F
9	480.	978.	927.	252.	41.	.408	.285	.122	44.5	2.17	.36	1.88	30.59	F
10	540.	986.	938.	278.	47.	.407	.285	.122	38.4	2.17	.36	1.88	30.59	F
11	600.	992.	947.	312.	53.	.407	.285	.122	32.3	2.17	.36	1.88	30.59	F
12	660.	998.	955.	343.	57.	.407	.285	.122	26.2	2.16	.36	1.88	30.59	F
13	720.	1002.	961.	363.	61.	.407	.285	.122	20.1	2.16	.36	1.88	30.59	F
14	780.	1007.	967.	379.	64.	.406	.284	.122	14.0	2.16	.36	1.88	30.59	F
15	840.	1010.	972.	392.	67.	.406	.284	.122	7.9	2.16	.36	1.88	30.59	F
16	900.	1013.	976.	403.	69.	.406	.284	.122	1.8	2.16	.36	1.88	30.59	F
17	960.	1015.	980.	416.	72.	.406	.284	.122	.0	2.16	.36	1.88	30.59	F
18	1020.	426.	606.	428.	73.	.000	.000	.000	.0	2.47	.43	1.79	28.92	T
19	1080.	296.	459.	433.	74.	.000	.000	.000	.0	2.39	.45	1.67	28.92	T
20	1140.	239.	385.	419.	76.	.000	.000	.000	.0	2.30	.45	1.58	28.92	T
21	1200.	203.	335.	392.	77.	.000	.000	.000	.0	2.22	.46	1.50	28.92	T
22	1260.	178.	298.	364.	78.	.000	.000	.000	.0	2.15	.47	1.44	28.92	T
23	1320.	160.	269.	337.	79.	.000	.000	.000	.0	2.08	.47	1.38	28.92	T
24	1380.	145.	245.	312.	80.	.000	.000	.000	.0	2.02	.47	1.33	28.92	T
25	1440.	134.	226.	290.	81.	.000	.000	.000	.0	1.96	.47	1.29	28.92	T
26	1500.	124.	209.	271.	81.	.000	.000	.000	.0	1.91	.48	1.25	28.92	T
27	1560.	115.	194.	255.	82.	.000	.000	.000	.0	1.85	.48	1.21	28.92	T
28	1620.	108.	181.	240.	82.	.000	.000	.000	.0	1.80	.48	1.17	28.92	T
29	1680.	102.	170.	227.	82.	.000	.000	.000	.0	1.76	.48	1.14	28.92	T
30	1740.	96.	160.	216.	82.	.000	.000	.000	.0	1.71	.48	1.11	28.92	T
31	1800.	92.	152.	205.	83.	.000	.000	.000	.0	1.67	.48	1.08	28.92	T
32	1860.	87.	144.	196.	83.	.000	.000	.000	.0	1.63	.48	1.05	28.92	T
33	1920.	84.	137.	187.	83.	.000	.000	.000	.0	1.60	.48	1.03	28.92	T
34	1980.	80.	131.	179.	83.	.000	.000	.000	.0	1.56	.49	1.00	28.92	T
35	2040.	77.	125.	172.	83.	.000	.000	.000	.0	1.53	.49	.98	28.92	T

VENTILATION SPECIFIED, FUEL PYROLYSIS ADJUSTED FOR WORST CONDITIONS PAGE NO. 1 RUN NO. 8

TIME	GAS FLOW PCT	HEAT BALANCE WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	48.339	4.946	14.745	32.022	4.419+06	1.240+08	.057	.648	.180	.073	.047
60.	58.154	8.318	5.410	28.134	4.363+06	2.118+08	.057	.648	.180	.073	.047
120.	60.694	9.415	4.060	25.768	4.347+06	2.896+08	.057	.648	.180	.073	.047
180.	62.608	10.308	3.244	23.808	4.334+06	3.599+08	.057	.648	.180	.073	.047
240.	64.103	11.047	2.695	22.137	4.324+06	4.244+08	.057	.648	.180	.073	.047
300.	65.155	11.590	2.344	20.860	4.317+06	4.845+08	.057	.648	.180	.073	.047
360.	66.052	12.068	2.081	19.804	4.310+06	5.411+08	.057	.648	.180	.073	.047
420.	66.825	12.493	1.862	18.807	4.305+06	5.945+08	.057	.648	.180	.073	.047
480.	67.492	12.868	1.686	17.929	4.301+06	6.451+08	.057	.648	.180	.073	.047
540.	68.080	13.204	1.545	17.190	4.296+06	6.934+08	.057	.648	.180	.073	.047
600.	68.577	13.494	1.429	16.529	4.293+06	7.396+08	.057	.648	.180	.073	.047
660.	68.996	13.741	1.335	15.963	4.290+06	7.841+08	.057	.648	.180	.073	.047
720.	69.354	13.956	1.254	15.443	4.288+06	8.271+08	.057	.648	.180	.073	.047
780.	69.673	14.149	1.187	15.000	4.285+06	8.687+08	.057	.648	.180	.073	.047
840.	69.940	14.313	1.132	14.625	4.284+06	9.092+08	.057	.648	.180	.073	.047
900.	70.160	14.448	1.088	14.315	4.282+06	9.488+08	.057	.648	.180	.073	.047
960.	70.342	14.561	1.052	14.056	4.281+06	9.876+08	.057	.648	.180	.073	.047
1020.	95.334	4.666	-34.635	-65.520	0.000	9.876+08	.230	.770	.000	.000	.000
1080.	96.914	3.086	-47.715	-52.475	0.000	9.876+08	.230	.770	.000	.000	.000
1140.	97.433	2.567	-54.773	-45.402	0.000	9.876+08	.230	.770	.000	.000	.000
1200.	97.701	2.299	-59.342	-40.481	0.000	9.876+08	.230	.770	.000	.000	.000
1260.	97.857	2.143	-62.819	-37.109	0.000	9.876+08	.230	.770	.000	.000	.000
1320.	97.958	2.042	-65.406	-34.512	0.000	9.876+08	.230	.770	.000	.000	.000
1380.	98.025	1.975	-67.489	-32.461	0.000	9.876+08	.230	.770	.000	.000	.000
1440.	98.071	1.929	-69.232	-30.849	0.000	9.876+08	.230	.770	.000	.000	.000
1500.	98.101	1.899	-70.589	-29.483	0.000	9.876+08	.230	.770	.000	.000	.000
1560.	98.121	1.879	-71.719	-28.347	0.000	9.876+08	.230	.770	.000	.000	.000
1620.	98.133	1.867	-72.665	-27.396	0.000	9.876+08	.230	.770	.000	.000	.000
1680.	98.138	1.862	-73.461	-26.598	0.000	9.876+08	.230	.770	.000	.000	.000
1740.	98.138	1.862	-74.133	-25.925	0.000	9.876+08	.230	.770	.000	.000	.000
1800.	98.135	1.865	-74.703	-25.355	0.000	9.876+08	.230	.770	.000	.000	.000
1860.	98.128	1.872	-75.188	-24.871	0.000	9.876+08	.230	.770	.000	.000	.000
1920.	98.119	1.881	-75.603	-24.459	0.000	9.876+08	.230	.770	.000	.000	.000
1980.	98.108	1.892	-75.960	-24.108	0.000	9.876+08	.230	.770	.000	.000	.000
2040.	98.095	1.905	-76.269	-23.809	0.000	9.876+08	.230	.770	.000	.000	.000

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TEST PROGRAM FOR PFLFIX ROUTINE. POOL OPTION

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =    20.00 M2
WINDOW HEIGHT =      1.50 M
         AREA =    10.00 M2
OPENING FACTOR =  12.247 M2.5
DISCHARGE COEFF.=  .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2
TOTAL ENTHALPY OF PYROLYSIS=    2.40+06 J/KG
BOILING TEMPERATURE= 390. DEG C

FUEL COMPOSITION
CARBON    = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN    =   .0 PERCENT
NITROGEN =   .0 PERCENT
WATER     =   .0 PERCENT
R = 14.78
RO=  3.43
HEAT OF COMBUSTION OF DRY FUEL =   46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =   43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYROLYSATES BURNED =   .70
GREY-GAS FLAME EMISSIVITY =  .900
FUEL AREA=      5.00 M2

----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =    .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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FUEL PYROLYSIS (POOL) SPECIFIED. VENTILATION ADJUSTED FOR WORST CONDITIONS PAGE NO. 1 RUN NO. 9

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL	WINDOW WIDTH
1	0.	1051.	866.	27.	25.	.388	.271	.116	94.2	5.73	.37	1.93	29.93	F	4.67
2	60.	1126.	1052.	39.	25.	.457	.267	.190	87.3	5.63	.36	1.93	29.92	F	6.67
3	120.	1140.	1079.	70.	25.	.471	.266	.205	80.3	5.61	.36	1.93	29.92	F	6.67
4	180.	1154.	1104.	115.	26.	.485	.265	.220	73.0	5.59	.36	1.93	29.91	F	6.67
5	240.	1161.	1118.	165.	28.	.493	.264	.228	65.6	5.58	.36	1.93	29.91	F	6.67
6	300.	1166.	1128.	211.	32.	.499	.264	.234	58.1	5.58	.36	1.93	29.91	F	6.67
7	360.	1170.	1135.	254.	38.	.503	.264	.239	50.6	5.57	.36	1.93	29.91	F	6.67
8	420.	1174.	1141.	293.	46.	.507	.264	.243	43.0	5.57	.36	1.93	29.91	F	6.67
9	480.	1176.	1146.	329.	55.	.510	.263	.246	35.3	5.56	.36	1.93	29.91	F	6.67
10	540.	1178.	1150.	361.	65.	.512	.263	.249	27.7	5.56	.36	1.93	29.91	F	6.67
11	600.	1180.	1154.	390.	76.	.514	.263	.251	19.9	5.56	.36	1.92	29.91	F	6.67
12	660.	1182.	1156.	417.	87.	.516	.263	.253	12.2	5.55	.36	1.92	29.91	F	6.67
13	720.	1183.	1159.	442.	97.	.518	.263	.255	4.4	5.55	.36	1.92	29.91	F	6.67
14	780.	1185.	1161.	464.	107.	.519	.263	.256	.0	5.55	.36	1.92	29.91	F	6.67

FUEL PYROLYSIS (POOL) SPECIFIED. VENTILATION ADJUSTED FOR WORST CONDITIONS PAGE NO. 1 RUN NO. 9

TIME	HEAT BALANCE GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	62.235	10.328	3.130	22.170	1.177+07	1.787+08	.063	.721	.139	.057	.019
60.	68.003	18.755	.948	12.241	1.157+07	2.702+08	.063	.712	.138	.056	.031
120.	69.104	19.586	.734	10.578	1.153+07	3.484+08	.062	.710	.137	.056	.034
180.	70.153	20.397	.551	8.900	1.149+07	4.136+08	.062	.709	.137	.056	.036
240.	70.729	20.849	.461	7.962	1.147+07	4.715+08	.062	.708	.137	.056	.037
300.	71.176	21.204	.396	7.225	1.145+07	5.239+08	.062	.707	.137	.056	.039
360.	71.507	21.469	.351	6.674	1.144+07	5.721+08	.062	.706	.136	.056	.039
420.	71.773	21.683	.316	6.229	1.143+07	6.170+08	.062	.706	.136	.056	.040
480.	71.990	21.859	.288	5.864	1.142+07	6.591+08	.062	.705	.136	.056	.040
540.	72.172	22.007	.266	5.556	1.142+07	6.990+08	.062	.705	.136	.056	.041
600.	72.327	22.134	.247	5.292	1.141+07	7.369+08	.062	.705	.136	.056	.041
660.	72.462	22.244	.231	5.062	1.140+07	7.731+08	.062	.705	.136	.056	.042
720.	72.581	22.342	.218	4.859	1.140+07	8.079+08	.062	.704	.136	.056	.042
780.	72.686	22.428	.206	4.679	1.140+07	8.413+08	.062	.704	.136	.056	.042

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TEST PROGRAM FOR RPFIX ROUTINE

----GEOMETRY AND VENTILATION----

WALL SURFACE AREA =      80.0 M2
FLOOR AREA =     20.00 M2
WINDOW HEIGHT =       1.50 M
        AREA =     10.00 M2
OPENING FACTOR =  12.247 M2.5
DISCHARGE COEFF.=  .68


----FUEL LOAD PROPERTIES----

FIRE LOAD PER FLOOR AREA =  20.0 KG/M2

FUEL COMPOSITION
CARBON    = 85.7 PERCENT BY WEIGHT
HYDROGEN = 14.3 PERCENT
OXYGEN    =    .0 PERCENT
NITROGEN =    .0 PERCENT
WATER     =    .0 PERCENT
R = 14.78
R0=  3.43
HEAT OF COMBUSTION OF DRY FUEL =   46.50+06 J/KG
LOWER ACTUAL HEAT OF COMBUSTION =   43.36+06 J/KG
MOLECULAR WEIGHT OF UNBURNT PYROLYSATES =  28.97
CP OF PYROLYSIS GAS = ( .1127*TGAS +  1010.) J/KG-K
MAXIMUM FRACTION OF PYRCLYSATES BURNED =    .70
GREY-GAS FLAME EMISSIVITY =  .900

RATE OF PYROLYSIS  (KG/S)
   TIME       RP
     0.      .120
   120.      .120
   121.      .250


----WALL THERMAL PROPERTIES----

THICKNESS =  .038 M
DENSITY =   790. KG/M3

THERMAL CONDUCTIVITY =     .170 W/M-K

HEAT CAPACITY =    840. J/KG-K

EMISSIVITY =  .50
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INPUTTED VALUES OF RP ARE USED PAGE NO. 1 RUN NO. 10

	TIME S	TEMP GAS.C	WALL TEMPS C			RP KG/S	RC KG/S	EXC.PYR. KG/S	FUEL PCT	AIR IN KG/S	N.P.	VELOCITY M/S	MOL.WT	FUEL CNTRL
1	0.	432.	234.	26.	25.	.120	.084	.036	98.2	6.11	.43	1.79	29.23	T
2	60.	457.	323.	29.	25.	.120	.084	.036	96.4	6.13	.42	1.80	29.23	T
3	120.	467.	355.	37.	25.	.120	.084	.036	94.6	6.13	.42	1.81	29.23	T
4	180.	805.	666.	51.	25.	.250	.175	.075	90.9	5.98	.39	1.91	29.56	T
5	240.	843.	756.	71.	26.	.250	.175	.075	87.1	5.95	.39	1.92	29.56	T
6	300.	856.	784.	97.	27.	.250	.175	.075	83.4	5.94	.39	1.92	29.56	T
7	360.	866.	804.	128.	29.	.250	.175	.075	79.6	5.94	.39	1.92	29.56	T
8	420.	872.	817.	160.	32.	.250	.175	.075	75.9	5.93	.38	1.92	29.57	T
9	480.	877.	827.	190.	37.	.250	.175	.075	72.1	5.93	.38	1.92	29.57	T
10	540.	881.	835.	218.	42.	.250	.175	.075	68.4	5.93	.38	1.92	29.57	T
11	600.	884.	841.	244.	49.	.250	.175	.075	64.6	5.92	.38	1.92	29.57	T
12	660.	887.	846.	267.	56.	.250	.175	.075	60.9	5.92	.38	1.92	29.57	T
13	720.	889.	851.	289.	64.	.250	.175	.075	57.1	5.92	.38	1.92	29.57	T
14	780.	891.	855.	309.	72.	.250	.175	.075	53.4	5.92	.38	1.92	29.57	T
15	840.	893.	858.	327.	80.	.250	.175	.075	49.6	5.92	.38	1.92	29.57	T
16	900.	894.	861.	344.	88.	.250	.175	.075	45.9	5.92	.38	1.92	29.57	T
17	960.	896.	864.	360.	95.	.250	.175	.075	42.1	5.92	.38	1.92	29.57	T
18	1020.	897.	866.	375.	102.	.250	.175	.075	38.4	5.91	.38	1.92	29.57	T
19	1080.	898.	868.	389.	109.	.250	.175	.075	34.6	5.91	.38	1.92	29.57	T
20	1140.	899.	870.	401.	116.	.250	.175	.075	30.9	5.91	.38	1.92	29.57	T
21	1200.	900.	872.	413.	122.	.250	.175	.075	27.1	5.91	.38	1.92	29.57	T
22	1260.	901.	874.	425.	127.	.250	.175	.075	23.4	5.91	.38	1.93	29.57	T
23	1320.	902.	876.	435.	133.	.250	.175	.075	19.6	5.91	.38	1.93	29.57	T
24	1380.	903.	877.	445.	138.	.250	.175	.075	15.9	5.91	.38	1.93	29.57	T
25	1440.	904.	878.	454.	142.	.250	.175	.075	12.1	5.91	.38	1.93	29.57	T
26	1500.	904.	880.	463.	147.	.250	.175	.075	8.4	5.91	.38	1.93	29.57	T
27	1560.	905.	881.	471.	151.	.250	.175	.075	4.6	5.91	.38	1.93	29.57	T
28	1620.	905.	882.	478.	154.	.250	.175	.075	.9	5.91	.38	1.93	29.57	T
29	1680.	906.	883.	485.	158.	.250	.175	.075	.0	5.91	.38	1.93	29.57	T
30	1740.	206.	476.	491.	161.	.000	.000	.000	.0	5.58	.46	1.51	28.92	T
31	1800.	148.	357.	491.	164.	.000	.000	.000	.0	5.08	.47	1.34	28.92	T
32	1860.	126.	307.	481.	167.	.000	.000	.000	.0	4.80	.48	1.26	28.92	T
33	1920.	112.	272.	464.	169.	.000	.000	.000	.0	4.58	.48	1.19	28.92	T

INPUTTED VALUES OF RP ARE USED PAGE NO. 1 RUN NO. 10

TIME	HEAT BALANCE										
	GAS FLOW PCT	WND RAD PCT	WALL CNV PCT	WALL RAD PCT	Q-FIRE W	Q-WALL SUM J	YO2 PCT MASS	YN2 PCT MASS	YCO2 PCT MASS	YH2O PCT MASS	YPYR PCT MASS
0.	75.919	3.719	11.044	9.317	3.642+06	4.450+07	.179	.755	.042	.017	.006
60.	80.960	4.296	6.596	8.147	3.642+06	7.672+07	.179	.755	.042	.017	.006
120.	82.877	4.533	5.171	7.419	3.642+06	1.042+08	.180	.755	.042	.017	.006
180.	72.523	10.016	3.312	14.154	7.588+06	1.837+08	.124	.739	.088	.036	.012
240.	76.015	11.532	1.779	10.659	7.588+06	2.404+08	.124	.739	.089	.036	.012
300.	77.201	12.086	1.379	9.318	7.588+06	2.891+08	.124	.739	.089	.036	.012
360.	78.063	12.502	1.122	8.308	7.588+06	3.320+08	.124	.739	.089	.036	.012
420.	78.650	12.792	.963	7.606	7.588+06	3.710+08	.124	.739	.089	.036	.012
480.	79.090	13.013	.848	7.049	7.588+06	4.070+08	.124	.739	.089	.036	.012
540.	79.441	13.191	.762	6.606	7.588+06	4.405+08	.124	.739	.089	.036	.012
600.	79.729	13.339	.694	6.239	7.588+06	4.721+08	.123	.739	.089	.036	.012
660.	79.970	13.464	.639	5.927	7.588+06	5.020+08	.123	.739	.089	.036	.012
720.	80.176	13.571	.594	5.659	7.588+06	5.305+08	.123	.739	.089	.037	.012
780.	80.355	13.665	.556	5.424	7.588+06	5.577+08	.123	.739	.089	.037	.012
840.	80.513	13.748	.523	5.217	7.588+06	5.838+08	.123	.739	.089	.037	.012
900.	80.653	13.822	.494	5.031	7.588+06	6.090+08	.123	.739	.089	.037	.012
960.	80.778	13.889	.469	4.864	7.588+06	6.332+08	.123	.739	.089	.037	.012
1020.	80.892	13.949	.447	4.712	7.588+06	6.567+08	.123	.739	.089	.037	.012
1080.	80.996	14.005	.427	4.573	7.588+06	6.795+08	.123	.739	.089	.037	.012
1140.	81.090	14.055	.409	4.445	7.588+06	7.016+08	.123	.739	.089	.037	.012
1200.	81.178	14.102	.393	4.328	7.588+06	7.231+08	.123	.739	.089	.037	.012
1260.	81.258	14.146	.378	4.219	7.588+06	7.440+08	.123	.739	.089	.037	.012
1320.	81.333	14.186	.364	4.117	7.588+06	7.644+08	.123	.739	.089	.037	.012
1380.	81.402	14.224	.352	4.023	7.588+06	7.843+08	.123	.739	.089	.037	.012
1440.	81.466	14.258	.340	3.935	7.588+06	8.038+08	.123	.739	.089	.037	.012
1500.	81.526	14.291	.330	3.853	7.588+06	8.228+08	.123	.739	.089	.037	.012
1560.	81.582	14.322	.320	3.776	7.588+06	8.415+08	.123	.739	.089	.037	.012
1620.	81.635	14.350	.311	3.704	7.588+06	8.598+08	.123	.739	.089	.037	.012
1680.	81.683	14.377	.303	3.637	7.588+06	8.777+08	.123	.739	.089	.037	.012
1740.	97.678	2.322	-55.416	-44.732	0.000	8.777+08	.230	.770	.000	.000	.000
1800.	98.014	1.986	-64.641	-35.282	0.000	8.777+08	.230	.770	.000	.000	.000
1860.	98.094	1.906	-68.298	-31.506	0.000	8.777+08	.230	.770	.000	.000	.000
1920.	98.127	1.873	-70.817	-29.066	0.000	8.777+08	.230	.770	.000	.000	.000

APPENDIX B -- PROGRAM LISTING

```
C
C          COMPF2--MAIN PROGRAM
C          CONSTITUTES REVISION OF PROGRAM COMPF
C          COMPF2 VERSION 1.0 PROGRAMMED 1 MARCH 1978 BY V. BABRAUSKAS
C          VERSION 1.1  MINOR REVISIONS  18 AUG 1978
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /TITLE/  TITLE(14)
      COMMON /CPLOT/  BUFX(500),BUFY(500),SCALX,SCALY,SPECS(30)
      INTEGER TITLE
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPLT,NEWPRP, PLFUEL,
     1   PLOT,PNCH,RPSPEC,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
C
      DATA ADIA,CD,CFLPC,CNV,CPA,DENSA,EF,G
     1   /.FALSE.,0.68,44.4,5.0,1005.,1.18,0.9,9.8/,
     2   HFLPC,IRUN,IX,MTIME,MWPYR,NEWPRP
     3   /5.4,0,10,360.,28.97,.TRUE./,
     4   NFLPC,OFLPC,PLOT,PNCH,REGRES,SH,SHAPE
     5   /0.0, 38.2, .FALSE., .FALSE.,0.0,0.0,2./,
     6   SIGMA,SIZE1,STEADY,TINPT,WFLPC
     7   /5.6697E-8,-10.,.FALSE.,0.0,12.0/
C        HEAT CAPACITIES ARE GIVEN IN THE FORM  CP(1)*TEMP+CP(2)
      DATA  CPCO   /0.1185, 1018./,
     1      CPCO2  /0.2114, 931./,
     2      CPH2O  /0.3549, 1814./,
     3      CPH2   /0.6862, 13966./,
     4      CPO2   /0.3704, 931./,
     5      CPN2   /0.1127, 1010./,
     6      CPPYR  /0.1127, 1010./
C        PROPERTIES OF PYROLYSIS GASES ARE ASSUMED SAME AS FOR NITROGEN
C
      NAMELIST /VARS/ ADIA,AFLOOR,AWALL,AWDOW,BPF,CD,CFLPC,CPPYR,CVGROS,
     1   DENSW,DHP,DTIME,EF,EISCAN,EITA,FLOAD,FLSPEC,HFLPC,HWDOW,
     2   IRUN,IX,KTRACE,MTIME,MWPYR,NEWPLT,NEWPRP,NFLPC,OFLPC,PLFUEL,
     3   PLOT,PNCH,PRNT,REGRES,RPSPEC,SH,SHAPE,SIZE,STEADY,STOICH,
     4   TINPT,THICKW,TBOILC,VTSPEC,WFLPC,  SCALX,SCALY
   10 READ (1,900,END=150) TITLE
  900 FORMAT (13A6,A2)
      WRITE(2,910) TITLE
  910 FORMAT(1H1,13A6,A2)
      EISCAN=.FALSE.
      STOICH=.FALSE.
```

```
      STEADY=.FALSE.
      KITER= 0
      TINPT= 0.
      KNTRL= 1
      KTRACE= 0
      NEWPLT= .FALSE.
      RPSPEC= .FALSE.
      FLSPEC= .FALSE.
      VTSPEC= .FALSE.
      PLFUEL= .FALSE.
      IRUN= IRUN+1
   20 READ (1,VARS)
      WRITE (5,VARS)
      IF(ADIA.OR.EISCAN.OR.STOICH) STEADY=.TRUE.
      IF (PNCH) PUNCH 900, TITLE
      IF (NEWPLT.AND.PLOT) CALL PLTRST
      IF (NEWPRP) CALL INC
      NEWPRP= .FALSE.
   30 CALL ICONDS
      IF (KNTRL.EQ.2) GOTO 10
      IF (KTRACE.NE.1)GOTO 50
   40 WRITE (4,901) IRUN
  901 FORMAT ('1 RUN NO.',I4//
     1    ' TGAS1     TGAS2      F1         F2        DERIV1    K KD '
     2    'KH    J   T2(1)     TSF        QFIRE      QFLOW      QRADW    '
     3    '    RP         RC    '/)
   50 IF (KITER.EQ.1) GO TO 60
      CALL ECHOID
   60 IF (RPSPEC) GOTO 70
      IF (FLSPEC) GOTO 80
      IF (VTSPEC) GOTO 90
      IF (PLFUEL.AND..NOT.FLSPEC) GOTO 100
      CALL CRIB
      GOTO 110
   70 CALL RPFIX
      GOTO 110
   80 CALL PFLFIX
      GOTO 110
   90 CALL PVTFIX
      GOTO 110
  100 CALL POOL
  110 GO TO (120,10,130,120),KNTRL
C         KNTRL= 1 INITIAL VALUE
C         KNTRL= 2 INPUT ERROR DETECTED, PROCEED TO NEW RUN
C         KNTRL= 3 ITERATION FAILURE--PRINT OUT STEPS EVEN IF KTRACE= 0.
C         KNTRL= 4 SIMULATION TIME LIMIT EXCEEDED
  120 CONTINUE
C          INSERT HERE ANY REWIND COMMAND TO BE DONE IF NO ERROR
      IF (PLOT.OR.PNCH) CALL DOUT
      GO TO 10
  130 IF (KTRACE.EQ.1) GOTO 10
  140 KTRACE= 1
      KITER= 1
      WRITE (2,903) TGAS
  903 FORMAT ('0---ITERATION FAILURE---'/' TGAS=',F16.2)
      GO TO 30
  150 CONTINUE
C     ENDFILE 5
      STOP
      END
```

```
      SUBROUTINE CRIB
C
C         CRIB FIRE ROUTINE
C         EQUATIONS FOLLOW NILSSON'S DATA FOR WOOD CRIBS.
C         OTHER FUEL CRIBS CAN BE TREATED IF PYROLYSIS CONSTANTS
C         ARE KNOWN.
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /QS/     QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/   BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1   WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,SCAN,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
      IF (STEADY) GOTO 190
      FC= .FALSE.
      SCAN= .FALSE.
      QRADW=0.
      QCONW= 0.
      F2=0.
      F1=0.
      DTGAS=10.
      CALL HEADNG
C          START TIME LOOP
      DO 170 J=1,JM
      KH= 0
      DERIV1= 1.
      TGAS2= 0.
      TGAS1= 0.
      TGASP= 2000.
      TGASN= TAMB
   20 CONTINUE
      K= 0
   30 CONTINUE
      IF (FLREM.GT.0.) GOTO 40
      RC= 0.
      RP= 0.
      GO TO 50
   40 IF (REGRES.LE.0.0) GOTO 45
C         USE THIS FORMULA IF INPUT REGRES IS SPECIFIED
      RP= REGRES*2.*SHAPE/SIZE*FLREM**(1.-1./SHAPE)*WTFUEL**(1./SHAPE)
      GO TO 50
   45 CONTINUE
```

```
C          FUEL SURFACE CONTROL
C          ASSUME CRIB STICK DENSITY RHOCR= 500 KG/M**3
      RHOCR= 500.
      REGREN= 1.24E-3/RHOCR*SIZE**-0.6
      RP1= REGREN*2.*SHAPE/SIZE*FLREM**(1.-1./SHAPE)*WTFUEL**(1./SHAPE)
C          CRIB POROSITY CONTROL
      RP2= 0.22*WTFUEL/(RHOCR*SIZE)*SH
C          ROOM VENTILATION CONTROL
      RP3= 0.120*AWDOW*SQRT(HWDOW)
      RP= AMIN1 (RP1,RP2,RP3)
   50 RMF= RMA+RP
      YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
      IF(YPYR.LT..0) YPYR= 0.
      MWOUT= 44.*YCO2+18.*YH2O+28.*YN2+32.*YO2+MWPYR*YPYR
      HRATIO= 1./(1.+((TGAS/TAMB)*(MWIN/MWOUT)*(1.+RP/RMA)**2)
     1    **0.3333333333)
C          NOTE HIN IS TAKEN AS POSITIVE
      HIN= HWDOW* HRATIO
      ZW=1.-MWOUT*TAMB/MWIN/TGAS
      IF(ZW)195,55,55
   55 VAVGIN= 0.666667*SQRT(2.*G*HIN*ZW)
      RMA= CD*VAVGIN*HIN*BWDOW*DENSA
      RMF= RMA+RP
      IF (RMA/R-RP) 60,60,65
   60 RC= BPF*RMA/R
      GO TO 70
   65 RC= BPF*RP
      FC= .TRUE.
   70 CONTINUE
      QFLOW= RMF*(YCO2*(TGAS*(0.5*CPCO2(1)*TGAS+CPCO2(2))-TAMB*(0.5*
     1    CPCO2(1)*TAMB+CPCO2(2))) +YH2O*(TGAS*(0.5*CPH2O(1)*TGAS+
     2    CPH2O(2))-TAMB*(0.5*CPH2O(1)*TAMB+CPH2O(2))) +YO2*(TGAS*(
     3    0.5*CPO2(1)*TGAS+CPO2(2))-TAMB*(0.5*CPO2(1)*TAMB+CPO2(2)))
     4    +YN2*(TGAS*(0.5*CPN2(1)*TGAS+CPN2(2))-TAMB*(0.5*CPN2(1)*
     5    TAMB+CPN2(2))) +YPYR*(TGAS*(0.5*CPPYR(1)*TGAS+CPPYR(2))
     6    -TAMB*(0.5*CPPYR(1)*TAMB+CPPYR(2))))
      QFIRE= RC*CVNET
      IF (ADIA) GOTO 90
      CALL DESOLV
      QRADW= AWALLN*EMS(1)*SIGMA*(TGAS**4.-TSF**4.)
      QCONW= AWALLN*(TGAS-TSF)*CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
   90 CONTINUE
      QRADO= AWDOW*SIGMA*(TGAS**4.-TAMB**4.)
      K= K+1
      F3=F2
      F2=F1
      F1= QFIRE-QFLOW-QRADO-QRADW-QCONW
      TGAS3=TGAS2
      TGAS2=TGAS1
      TGAS1=TGAS
      IF (F1.LT.0..AND.TGAS.LT.TGASP) TGASP=TGAS
      IF (F1.GT.0..AND.TGAS.GT.TGASN) TGASN=TGAS
      DERIV2= DERIV1
      IF (TGAS1.EQ.TGAS2) GOTO 130
```

```
      DERIV1=(F1-F2)/(TGAS1-TGAS2)
      IF (KTRACE.GT.0) WRITE (4,99) TGAS1,TGAS2,F1,F2,DERIV1,K,KD,
     1   KH,J,T2(1),TSF,QFIRE,QFLOW,QRADW,RP,RC
   99 FORMAT(2F9.2,3(1PE9.2),3I3,I5,2(0PF9.2),3(1PE10.3),2(0PF7.3))
      IF (.NOT.SCAN) GOTO 95
      IF (F1/F2.GE.0.0) GOTO 93
      SCAN= .FALSE.
      GOTO 100
   93 TGAS= TGAS-DTGAS
      IF (TGAS.LT.TAMB) GOTO 200
      GOTO 120
   95 IF (DERIV1.LT..0.AND.ABS(F2).GT..0001)GOTO 100
      IF(DERIV2.LT..0.AND.J.GT.2) GOTO 100
      TGAS= TGAS1+DTGAS/5.
      GOTO 120
  100 DIF= ABS(F1/QFLOW)
      IF (DIF.LT.0.002.AND.ABS(TGAS2-TGAS1).LT.2.) GOTO 130
      TGAS=(F1*TGAS2-F2*TGAS1)/(F1-F2)
      IF (K.GT.10.AND.F1.LT.0..AND.TGAS.GT.TGASP) GOTO 105
      IF (K.GT.10.AND.F1.GT.0..AND.TGAS.LT.TGASN) GOTO 105
      IF (K.EQ.1.AND.KH.EQ.0) TGAS= TGAS1 +10.
      IF (TGAS.GT.2000.) GOTO 110
      IF (TGAS.LT.(TAMB+30.)) GOTO 110
      GOTO 120
  105 TGAS= (TGASN+TGASP)/2.
      GOTO 120
  110 SCAN= .TRUE.
      TGAS= 1900.
  120 CONTINUE
      IF (K-200) 30,30,200
  130 CONTINUE
      CALL RSTA
      FLREM= FLREM-RP*DTIME
      IF(FLREM.LT.0.) FLREM=0.
      IF (QCONW.GT.0.) QWLSUM= QWLSUM+(QRADW+QCONW)*DTIME
      IF (TTIME .GE. MTIME) GO TO 210
      IF (TGAS.LE.353..AND.J.GE.10) GO TO 210
      IF (J.EQ.1) GO TO 150
      IF (JP.LT.JPRINT) GO TO 160
      JP= 0
  150 CALL OUTPUT
  160 JP= JP+1
      TTIME= TTIME+DTIME
  170 CONTINUE
C        END TIME STEP DO-LOOP
  180 CONTINUE
  185 CALL OUTPUT
      RETURN
C         ERROR IN INPUT
  190 CONTINUE
      KNTRL= 2
      WRITE (2,910)
  910 FORMAT (///' CRIB ROUTINE DOES NOT ACCEPT STEADY-STATE CASE')
      RETURN
C        SQUARE ROOT ERROR
  195 CONTINUE
      IF(KTRACE.EQ.1) WRITE(2,930) TGAS,RC,RP,YPYR,ZW,RMA,MWOUT
  930 FORMAT (/' TGAS=',F5.0,' RC=',E10.4,' RP=',E10.4,
```

```
    1  ' YPYR=',E10.4,' ZW=',F6.4,' RMA=',E10.4,' MWOUT=',F6.1)
C         FAIL TO CONVERGE, ERROR EXIT
  200 CONTINUE
      KNTRL=3
      RETURN
C         FIRE IS OVER (TRANSIENT CASE)
  210 CONTINUE
      CALL OUTPUT
      RETURN
      END
```

```
      SUBROUTINE DEQNS
C
C        DIFFERENTIAL EQUATION SOLVER BASED ON  CRANK-NICOLSON METHOD.
C
      COMMON /GP/      AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      DIMENSION A(20),B(20),C(20),CND(20),D(20),HCP(20)
C
      ENTRY RSTA
C
C        ENTER HERE WHEN READY FOR NEW TIME STEP (FINISHED ITERATING)
C
      DO 10 I=1,IX
      T1(I)= T2(I)
   10 CONTINUE
      TGOLD= TGAS
      IF (J.EQ.0) TGOLD=TAMB
      RETURN
C
      ENTRY DESOLV
C
C        SOLVE DIFFERENTIAL EQUATION
C
      KD= 1
      DX1= DX
      DO 20 I=1,IX
      CND(I)= TLU(CNDA,NCND,T1(I))
   20 HCP(I)= DENSW*DX/DTIME*TLU(CPW,NCPW,T1(I))
      EMS(1)= 1./(1./TLU(EMSA,NEMS,TSF) +1./EF -1.)
      EMS(2)= TLU(EMSA,NEMS,TSU)
      DO 50 I=2,IXL
      CNL= 1./(DX/CND(I-1)+DX/CND(I))
      IF (I.EQ.2 ) CNL= 1./(DX1/CND(1)+DX/CND(2))
      CNG= 1./(DX/CND(I)+DX/CND(I+1))
      A(I)= -CNL
      B(I)= HCP(I)+CNL+CNG
      C(I)= -CNG
      D(I)= (HCP(I)-CNL-CNG)*T1(I)+CNL*T1(I-1)+CNG*T1(I+1)
   50 IF (NQGEN.GT.0) D(I)= D(I)+DX*TLU(QGEN,NQGEN,T1(I))
      CNG= 1./(DX1/CND(1)+DX/CND(2))
      C(1)= -CNG
      CNL= 1./(DX/CND(IXL)+DX/CND(IX))
      A(IX)= -CNL
C
C        ENTER HERE WHEN KD.GT.1 SINCE PRIOR EXPRESSIONS DO NOT CHANGE
C
   30 TSFOLD= TSF
      ZRF= TGAS*(TGAS*(TGAS+TSF)+TSF*TSF)+TSF*TSF*TSF
      ZCF= CNV*((TGAS-TSF)*(TGAS-TSF))**0.1666666667
      HF= ZCF+SIGMA*EMS(1)*ZRF
      DENF= HF*DX1/2./CND(1)
      ZF= HF/2./(DENF+1.)
```

```
      B(1)= HCP(1)+ZF+CNG
      D(1)= (HCP(1)-ZF-CNG)*T1(1)+ZF*(TGAS+TGOLD)+CNG*T1(2)
      IF (NQGEN.GT.0) D(1)= D(1)+DX*TLU(QGEN,NQGEN,T1(1))
      ZRU= TAMB*(TAMB*(TAMB+TSU)+TSU*TSU)+TSU*TSU*TSU
      ZCU= 1.87*((TAMB-TSU)*(TAMB-TSU))**0.1666666667
      HU= ZCU+SIGMA*EMS(2)*ZRU
      DENU= HU*DX/2./CND(IX)
      ZU= HU/2./(DENU+1.)
      B(IX)= HCP(IX)+ZU+CNL
      D(IX)= (HCP(IX)-ZU-CNL)*T1(IX)+ZU*2.*TAMB+CNL*T1(IXL)
      IF (NQGEN.GT.0) D(IX)= D(IX)+DX*TLU(QGEN,NQGEN,T1(IX))
      CALL TRIDGF (A,B,C,D,T2,IX)
      TSF= (DENF*TGAS+T2(1))/(DENF+1.)
      TSU= (DENU*TAMB+T2(IX))/(DENU+1.)
      KD= KD+1
      IF (ABS(TSF-TSFOLD).LT.4) RETURN
      IF (KD.LE.6) GO TO 30
      WRITE (2,100) TSF,TSFOLD
  100 FORMAT ('0   FAIL TO CONVERGE D.E.  TSF=',F7.2,'   TSFOLD=' F7.2)
      IF (KD.LE.30) GO TO 30
      RETURN
      END
```

```
      SUBROUTINE ECHOID
C
C        SUBROUTINE TO ECHO INPUT DATA
C
      COMMON /CP/      CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/    C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/      AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/   FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/   ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,N,NFLPC
      WRITE (2,90) IRUN
      WRITE (2,91) AWALL, AFLOOR, HWDOW, AWDOW, OPENF, CD
      WRITE (2,92) FLOAD
      IF (PLFUEL) WRITE (2,93) DHP,TBOILC
      WRITE (2,94)  CFLPC,HFLPC,OFLPC,NFLPC,WFLPC,R,RO
      WRITE (2,95) CVGROS,CVNET,MWPYR,CPPYR,BPF,EF
      IF (.NOT.(PLFUEL.OR.VTSPEC.OR.RPSPEC)) WRITE (2,96) REGRES,SIZE,
     1   SHAPE
      IF (PLFUEL.AND..NOT.STOICH) WRITE (2,97) SIZE
      IF (.NOT.(PLFUEL.OR.VTSPEC.OR.RPSPEC).AND.SH.GT.0.0) WRITE (2,908)
     1   SH
      IF (RPSPEC.AND.NRP.EQ.1) WRITE (2,913) RPX(2,1)
      IF (RPSPEC.AND.NRP.NE.1) WRITE (2,914) ((RPX(I,J),I=1,2),J=1,NRP)
      IF(ADIA) GOTO 200
      WRITE (2,98) THICKW,DENSW
      IF (NCND.EQ.1) WRITE (2,900) CNDA(2,1)
      IF (NCND.GT.1) WRITE (2,901)((CNDA(I,J),I=1,2),J=1,NCND)
      IF (NCPW.EQ.1) WRITE (2,904) CPW(2,1)
      IF (NCPW.GT.1) WRITE (2,905)((CPW(I,J),I=1,2),J=1,NCPW)
      IF (NEMS.EQ.1) WRITE (2,902) EMSA(2,1)
      IF (NEMS.NE.1) WRITE (2,903)((EMSA(I,J),I=1,2),J=1,NEMS)
      IF (NQGEN.EQ.1) WRITE (2,906) QGEN(2,1)
      IF (NQGEN.GT.1) WRITE (2,907)((QGEN(I,J),I=1,2),J=1,NQGEN)
  200 IF(ADIA) WRITE(2,909)
      RETURN
   90 FORMAT (1H+, T86,'COMPF2 VERSION 1.1 - RUN NO.',I4)
   91 FORMAT ('0----GEOMETRY AND VENTILATION----'//
     1    ' WALL SURFACE AREA = ',F8.1,' M2'/
     2    ' FLOOR AREA = ',F8.2,' M2'/
     3    ' WINDOW HEIGHT = ',F8.2,' M'/
     4    '              AREA = ',F8.2,' M2'/
     5    ' OPENING FACTOR = ',F7.3,' M2.5'/
     6    ' DISCHARGE COEFF.= ',F4.2/)
   92 FORMAT ('0----FUEL LOAD PROPERTIES----'//
     1    ' FIRE LOAD PER FLOOR AREA =',F6.1,' KG/M2')
  913 FORMAT ('ORATE OF PYROLYSIS =',F7.2,' KG/S')
  914 FORMAT ('ORATE OF PYROLYSIS  (KG/S)'/'    TIME       RP'
```

```
   1    50(/3X,F5.0,F9.3))
 93 FORMAT (' TOTAL ENTHALPY OF PYROLYSIS= '
   1     ,1PE10.2,' J/KG'/' BOILING TEMPERATURE=',0PF5.0,' DEG C')
 94 FORMAT ('0FUEL COMPOSITION'/
   1     ' CARBON   = ',F4.1,' PERCENT BY WEIGHT'/
   2     ' HYDROGEN = ',F4.1,' PERCENT'/
   3     ' OXYGEN   = ',F4.1,' PERCENT'/
   4     ' NITROGEN = ',F4.1,' PERCENT'/
   5     ' WATER    = ',F4.1,' PERCENT'/
   6     ' R = ',F5.2/
   7     ' R0= ',F5.2)
 95 FORMAT  ( ' HEAT OF COMBUSTION OF DRY FUEL = ',2PE10.2,' J/KG'/
   1     ' LOWER ACTUAL HEAT OF COMBUSTION = ',E10.2,' J/KG'/
   2     ' MOLECULAR WEIGHT OF UNBURNT PYROLYSATES = ',0PF6.2/
   3     ' CP OF PYROLYSIS GAS = (',F6.4,'*TGAS + ',F6.0,
   4     ') J/KG-K'/
   5     ' MAXIMUM FRACTION OF PYROLYSATES BURNED = ',F5.2/
   6     ' GREY-GAS FLAME EMISSIVITY = 'F5.3)
 96 FORMAT (' RATE OF REGRESSION = ',2PE9.2,' M/S'/
   1     ' FUEL DIMENSION = ',0PF5.3,' M'/
   2     ' SHAPE FACTOR = ',F4.2 /)
 97 FORMAT (' FUEL AREA=',F10.2,' M2')
908 FORMAT (' CRIB SPACING/HEIGHT RATIO=',F6.3)
 98 FORMAT ('0----WALL THERMAL PROPERTIES----'//
   1     ' THICKNESS = ',F5.3,' M'/
   2     ' DENSITY = ',F6.0,' KG/M3')
909 FORMAT ('0----WALL THERMAL PROPERTIES----'//
   1        ' ADIABATIC WALL'//)
900 FORMAT ('0THERMAL CONDUCTIVITY = ',F7.3,' W/M-K')
901 FORMAT ('0THERMAL CONDUCTIVITY ARRAY (W/M-K)'/
   1     ' TEMPERATURE   CONDUCTIVITY', 10(/3X,F7.1,4X,F10.3))
902 FORMAT ('0EMISSIVITY = ',F4.2)
903 FORMAT ('0EMISSIVITY ARRAY'/' TEMPERATURE  EMISSIVITY'
   1     10(/3X,F7.1,4X,F10.3))
904 FORMAT ('0HEAT CAPACITY = ',F7.0,' J/KG-K')
905 FORMAT  ('0HEAT CAPACITY ARRAY (J/KG-K)'/
   1     ' TEMPERATURE   HEAT CAPACITY', 10(/3X,F7.1,4X,F10.0))
906 FORMAT ('0WALL HEAT GENERATED = ',F9.3,' W/M3')
907 FORMAT ('0WALL HEAT GENERATED ARRAY (W/M3)'/
   1     ' TEMPERATURE   QGEN',  10(/3X,F7.1,4X,F10.3))
    END
```

```
      SUBROUTINE ICONDS
C
C         SET INITIAL CONDITIONS AND CONSTANTS
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /QS/     QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/   BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1   WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,STEADY,STOICH
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
      FC= .FALSE.
      KNTRL= 1
      AWALLN= AWALL-AWDOW
      BWDOW= AWDOW/HWDOW
      WTFUEL= FLOAD*AFLOOR
      OPENF= AWDOW*SQRT(HWDOW)
      MWIN= 28.97
      MWOUT= MWIN
      TAMB= 298.
      TGAS= 1800.
      IF (TINPT.GT.0.) TGAS= TINPT
      IXL= IX-1
      IXC= IX/2
      TSF= TAMB
      TSU= TAMB
      DENF= 0.
      DENU= 0.
      WA= 6H
      WB= 5H
      IF (.NOT.FLSPEC) GO TO 10
      WA= 6HWINDOW
      WB= 5HWIDTH
   10 JP= 0
      IF (.NOT.STEADY) JPRINT= PRNT/DTIME + (1.0-1.E-6)
      IF (STEADY) GOTO 20
      IF (DTIME.GT.0.00001) GOTO 15
      WRITE (2,95)
      KNTRL= 2
      RETURN
   95 FORMAT (///' FOR NON-STEADY PROBLEMS MUST SPECIFY DTIME ',
     1   'GREATER THAN ZERO')
   15 IF (MTIME.GT.DTIME) GOTO 20
```

```
      WRITE (2,92)
   92 FORMAT (///' FOR NON-STEADY PROBLEMS MUST SPECIFY MTIME ',
     1    'GREATER THAN DTIME')
      KNTRL= 2
      RETURN
   20 CONTINUE
      IF (.NOT.STEADY) JM= MTIME/DTIME +2
      IF (STEADY) JM= 2
      DX= THICKW/IX
      FLREM= WTFUEL
      TTIME= 0.
      EMS(1)= 1./(1./TLU(EMSA,NEMS,TAMB) +1./EF -1.)
      QWLSUM= 0.
      DO 60 I=1,IX
   60 T2(I)= TAMB
      J= 0
      CALL RSTA
      TOTAL= CFLPC+HFLPC+OFLPC+NFLPC+WFLPC
      IF (TOTAL.LT.101.1.AND.TOTAL.GT.98.9) GOTO 70
C             CHECK FOR ERRORS IN FUEL COMPOSITION
      KNTRL= 2
      WRITE (2,90)
   90 FORMAT (///' SUM OF FUEL COMPOSITION INPUT IS INCORRECT')
      RETURN
   70 C= CFLPC*(10./12.)
      H= HFLPC*10.
      O= OFLPC*(10./16.)
      W= WFLPC*(10./18.)
      N= NFLPC*(10./14.)
      RO= (C+H/4.-O/2.)*32./1000.
      R= RO/0.232
      CVNET= CVGROS*(1.-WFLPC/100.)-(WFLPC+9.0*HFLPC)/100.*2440.E+3
C          LATENT HEAT OF H2O EVAPORATION= 2440E+3 J/KG AT 25 C
      RMA= 0.16*AWDOW*DENSA*SQRT(G*HWDOW)
      RMF= RMA
      RC= BPF*RMA/R
      YO2= 0.10
      IF (STOICH) EITA= 1.
      IF (EISCAN) SIZE= SIZE1/EITA
      RETURN
      END
```

```
      SUBROUTINE INC
C
C        ROUTINE TO INPUT ALL CONSTANTS NOT GIVEN IN NAMELIST -VARS-
C
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      NQGEN= 0
      READ (1,91) NCN,NCP,NEM,NR,NQG
      IF (NCN.EQ.0) GO TO 10
      NCND= NCN
      READ (1,90) (CNDA(1,I),CNDA(2,I),I=1,NCND)
   10 IF (NCP.EQ.0) GO TO 20
      NCPW= NCP
      READ (1,90) (CPW(1,I),CPW(2,I),I=1,NCPW)
   20 IF (NEM.EQ.0) GO TO 30
      NEMS= NEM
      READ (1,90) (EMSA(1,I),EMSA(2,I),I=1,NEMS)
   30 IF (NR.EQ.0) GO TO 40
      NRP= NR
      READ (1,90) (RPX(1,I),RPX(2,I),I=1,NRP)
      NQGEN= NQG
   40 IF (NQG.EQ.0) GO TO 50
      READ (1,90) (QGEN(1,I),QGEN(2,I),I=1,NQGEN)
   50 RETURN
   90 FORMAT (8F10.0)
   91 FORMAT (10I3)
      END
```

```
      SUBROUTINE OUTPUT
C
C        PRINTS OUTPUT DATA
C
      COMMON /FUEL/    C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1    OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/      AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1    J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1    RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1    PRNT,STEADY,THICKW
      COMMON /QS/      QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/    DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /WOUT/    BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1    WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1    PLOT,PNCH,RPSPEC,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,N,NFLPC
      LOGICAL DATPRT
      DIMENSION T2C(3)
      DATA DATPRT /.FALSE./
      IF (KITER.EQ.1) RETURN
      IF (PLOT.OR.PNCH) CALL DSTO    (TTIME,TGAS)
      IF (ILINE.LE.47) GO TO 50
      DATPRT= .TRUE.
      GO TO 300
   50 TGASC= TGAS-273.
      T2C(1)= TSF-273.
      T2C(2)= T2(IXC)-273.
      T2C(3)= TSU-273.
      FUELPC= FLREM/WTFUEL*100.
      QNORM= QFIRE/100.
      IF (QCONW.LT.0) QNORM= (QFLOW+QRADO)/100.
      ZFLOW= QFLOW/QNORM
      ZRADO= QRADO/QNORM
      ZCONW= QCONW/QNORM
      ZRADW= QRADW/QNORM
      EXCESS= RP-RC
      ILINE = ILINE+1
      WRITE (2,90) J,TTIME,TGASC,T2C,RP,RC,EXCESS,FUELPC,RMA,HRATIO,
     1    VAVGIN,MWOUT,FC
      IF (FLSPEC) WRITE (2,91) BWORST
      WRITE (3,92) TTIME,ZFLOW,ZRADO,ZCONW,ZRADW,QFIRE,QWLSUM,
     1    YO2,YN2,YCO2,YH2O,YPYR
      IF (STOICH) WRITE (2,901) SIZE1
      RETURN
C
      ENTRY HEADNG
C        START NEW PAGE
      IF (KITER.EQ.1) RETURN
      IPG = 1
  300 CONTINUE
      ILINE = 0
      IF (.NOT.RPSPEC) GOTO 315
      WRITE (2,94) IPG,IRUN
```

```
      WRITE (3,94) IPG,IRUN
      GO TO 400
  315 IF (.NOT.FLSPEC) GOTO 325
      IF (.NOT.PLFUEL) WRITE (2,95) IPG,IRUN
      IF (.NOT.PLFUEL) WRITE (3,95) IPG,IRUN
      IF (PLFUEL) WRITE (2,905) IPG,IRUN
      IF (PLFUEL) WRITE (3,905) IPG,IRUN
      GO TO 400
  325 IF (.NOT.VTSPEC) GOTO 335
      WRITE (2,96) IPG,IRUN
      WRITE (3,96) IPG,IRUN
      GO TO 400
  335 IF (.NOT.PLFUEL) GO TO 345
      WRITE (2,97) IPG,IRUN
      WRITE (3,97) IPG,IRUN
      GO TO 400
  345 WRITE (2,98) IPG,IRUN
      WRITE (3,98) IPG,IRUN
  400 IPG = IPG+1
      WRITE (2,99) WA,WB
      WRITE (3,900)
      IF (.NOT.DATPRT) RETURN
      DATPRT= .FALSE.
      GO TO 50
   90 FORMAT (1H ,I4,T6,F8.0,T15,F7.0,T25,3F6.0,T44,F6.3,T51,F6.3,
     1    T60,F6.3,T69,F5.1,T79,F4.2,T87,F7.2,T96,F9.2,T109,F6.2,5X,L1)
   91 FORMAT (1H+, T124, F6.2)
   92 FORMAT (1H ,F7.0,4F11.3,1PE15.3,E15.3,1X,0P(5F8.3))
   94 FORMAT (1H1,T14,' INPUTTED VALUES OF RP ARE USED'
     1    T100,'PAGE NO.',I3,T115,'RUN NO.',I4//)
   95 FORMAT (1H1,T14, ' FUEL PYROLYSIS (CRIB) SPECIFIED, VENTILATION '
     1    ' ADJUSTED FOR WORST CONDITIONS', T100,'PAGE NO.',I3,T115,
     2    'RUN NO.',I4//)
   96 FORMAT (1H1,T14,' VENTILATION SPECIFIED, FUEL PYROLYSIS ADJUSTED'
     1    ' FOR WORST CONDITIONS',T100,'PAGE NO.',I3,T115,'RUN NO.',I4/
     2    /)
   97 FORMAT (1H1,T14,' THERMOPLASTIC POOL FIRE',T100,'PAGE NO.'
     1    I3,T115,'RUN NO.', I4//)
   98 FORMAT (1H1,T14,'CRIB FIRE',T100,'PAGE NO.',I3,
     1    T115,'RUN NO.',I4/)
   99 FORMAT (1H0,T10,'TIME',T17,'TEMP',T30,'WALL TEMPS',T47,'RP',
     1    T54,'RC',T59,'EXC.PYR.',T70,'FUEL',T78,'AIR IN',T90,'N.P.',
     2    T98,'VELOCITY',T109,'MOL.WT',T118,'FUEL',T124,A6/
     3    T11,'S',T17,'GAS,C',T34,'C',T46,'KG/S',T53,'KG/S',T61,
     4    'KG/S',T71,'PCT',T79,'KG/S',T101,'M/S',T108,
     5    T118,'CNTRL',T124,A5/)
  900 FORMAT (T5,'TIME',T24,'HEAT BALANCE',T75,'Q-WALL',T88,'YO2',T96,
     2    'YN2',T104,'YCO2',T112,'YH2O',T120,'YPYR'/
     2    T13,'GAS FLOW',T25,'WND RAD',T36,'WALL CNV',T47,'WALL RAD',
     3    T60,'Q-FIRE',T76,'SUM',T88,'PCT',T96,'PCT',T104,'PCT',T112,
     4    'PCT',T120,'PCT'/
     5    T16,'PCT',T27,'PCT',T39,'PCT',T49,'PCT',T62,'W',T77,
     6    'J',T88,'MASS',T96,'MASS',T104,'MASS',T112,'MASS',
     7    T120,'MASS'/)
  901 FORMAT (//' STOICHIOMETRIC FUEL SIZE= ',F8.3,' M2')
  905 FORMAT (1H1,T14, ' FUEL PYROLYSIS (POOL) SPECIFIED, VENTILATION'
     1    ' ADJUSTED FOR WORST CONDITIONS', T100,'PAGE NO.',I3,T115,
     2    'RUN NO.',I4//)
      END
```

```
      SUBROUTINE PFLFIX
C
C
C        PESSIMIZATION ROUTINE
C        FIXED FUEL PYROLYSIS, WINDOW WIDTH VARIED FOR WORST
C        BURNING CONDITIONS.
C        EITHER CRIB OR POOL FUELS ACCEPTED
C        FOR POOL FUELS, MUST ALSO SET PLFUEL=.TRUE.
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /QS/     QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/   BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1   WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,SCAN,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
      IF (STEADY) GOTO 190
      FC= .FALSE.
      SCAN= .FALSE.
      QRADW=0.
      QCONW= 0.
      F2=0.
      F1=0.
      DTGAS=10.
      TBOIL=TBOILC+273.
      CALL HEADNG
C          START TIME LOOP
      DO 170 J=1,JM
      KH= 0
      DERIV1= 1.
      TGAS2= 0.
      TGAS1= 0.
      TGASP= 2000.
      TGASN= TAMB
   20 CONTINUE
      K= 0
   30 CONTINUE
      KR= 0
      RMA= 0.666667*CD*0.5*AWDOW*DENSA*SQRT(G*HWDOW*(1.-TAMB/TGAS))
      IF (FLREM) 220,220,35
C         AS SOON AS FUEL IS EXHAUSTED PROGRAM MUST STOP,
C         SINCE WINDOW SIZE WOULD NOT BE WELL DEFINED.
   35 IF (.NOT.PLFUEL) GOTO 40
```

```
      RP= SIZE*EF*SIGMA*(TGAS**4.-TBOIL**4.)/DHP
      PLUME= SIZE*0.0014*CVNET/DHP
      PROP= 1.-(TGAS**4.-TBOIL**4.)/(1700.**4.-TBOIL**4.)
      IF (PROP.LT.0.) PROP= 0.
      RP= RP+PROP*PLUME
      GO TO 50
   40 IF (REGRES.LE.0.0) GOTO 45
C        USE THIS FORMULA IF INPUT REGRES IS SPECIFIED
      RP= REGRES*2.*SHAPE/SIZE*FLREM**(1.-1./SHAPE)*WTFUEL**(1./SHAPE)
      GO TO 50
   45 CONTINUE
C        FUEL SURFACE CONTROL
C        ASSUME CRIB STICK DENSITY RHOCR= 500 KG/M**3
      RHOCR= 500.
      REGREN= 1.24E-3/RHOCR*SIZE**-0.6
      RP1= REGREN*2.*SHAPE/SIZE*FLREM**(1.-1./SHAPE)*WTFUEL**(1./SHAPE)
C        CRIB POROSITY CONTROL
      RP2= 0.22*WTFUEL/(RHOCR*SIZE)*SH
      RP= AMIN1 (RP1,RP2)
   50 RMF= RMA+ RP
      YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
      IF(YPYR.LT..0) YPYR= 0.
      MWOUT= 44.*YCO2+18.*YH2O+28.*YN2+32.*YO2+MWPYR*YPYR
      HRATIO= 1./(1.+((TGAS/TAMB)*(MWIN/MWOUT)*(1.+RP/RMA)**2)
     1   **0.3333333333)
C        NOTE HIN IS TAKEN AS POSITIVE
      HIN= HWDOW* HRATIO
      ZW=1.-MWOUT*TAMB/MWIN/TGAS
      IF(ZW)195,55,55
   55 VAVGIN= 0.666667*SQRT(2.*G*HIN*ZW)
      RMA= CD*VAVGIN*HIN*BWDOW*DENSA
      IF (RP-RMA/R) 60,60,65
   60 RC= RP*BPF
      BWORST= BWDOW*RC*R/RMA
      RMA= RC*R/BPF
      GO TO 70
   65 RC= BPF*RMA/R
      BWORST= BWDOW
C        RECALCULATE Y- VALUES SINCE RP,RC HAVE BEEN CHANGED
   70 KR= KR+1
      IF (KR-3) 50,75,75
   75 CONTINUE
      QFLOW= RMF*(YCO2*(TGAS*(0.5*CPCO2(1)*TGAS+CPCO2(2))-TAMB*(0.5*
     1   CPCO2(1)*TAMB+CPCO2(2))) +YH2O*(TGAS*(0.5*CPH2O(1)*TGAS+
     2   CPH2O(2))-TAMB*(0.5*CPH2O(1)*TAMB+CPH2O(2))) +YO2*(TGAS*(
     3   0.5*CPO2(1)*TGAS+CPO2(2))-TAMB*(0.5*CPO2(1)*TAMB+CPO2(2)))
     4   +YN2*(TGAS*(0.5*CPN2(1)*TGAS+CPN2(2))-TAMB*(0.5*CPN2(1)*
     5   TAMB+CPN2(2))) +YPYR*(TGAS*(0.5*CPPYR(1)*TGAS+CPPYR(2))
     6   -TAMB*(0.5*CPPYR(1)*TAMB+CPPYR(2))))
      QFIRE= RC*CVNET
      IF (ADIA) GOTO 90
      CALL DESOLV
      QRADW= AWALLN*EMS(1)*SIGMA*(TGAS**4.-TSF**4.)
      QCONW= AWALLN*(TGAS-TSF)*CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
```

```
 90 CONTINUE
    QRADO= HWDOW*BWORST*SIGMA*(TGAS**4.-TAMB**4.)
    K= K+1
    F3=F2
    F2=F1
    F1= QFIRE-QFLOW-QRADO-QRADW-QCONW
    TGAS3=TGAS2
    TGAS2=TGAS1
    TGAS1=TGAS
    IF (F1.LT.0..AND.TGAS.LT.TGASP) TGASP=TGAS
    IF (F1.GT.0..AND.TGAS.GT.TGASN) TGASN=TGAS
    DERIV2= DERIV1
    IF (TGAS1.EQ.TGAS2) GOTO 130
    DERIV1=(F1-F2)/(TGAS1-TGAS2)
    IF (KTRACE.GT.0) WRITE (4,99) TGAS1,TGAS2,F1,F2,DERIV1,K,KD,
   1    KH,J,T2(1),TSF,QFIRE,QFLOW,QRADW,RP,RC
 99 FORMAT(2F9.2,3(1PE9.2),3I3,I5,2(0PF9.2),3(1PE10.3),2(0PF7.3))
    IF (.NOT.SCAN) GOTO 95
    IF (F1/F2.GE.0.0) GOTO 93
    SCAN= .FALSE.
    GOTO 100
 93 TGAS= TGAS-DTGAS
    IF ((PLFUEL.AND.(TGAS.LT.TBOIL)).OR.(TGAS.LT.TAMB)) GOTO 200
    GOTO 120
 95 IF (DERIV2.LT..0.AND.ABS(F2).GT..0001)GOTO 100
    IF(DERIV2.LT..0.AND.J.GT.2) GOTO 100
    TGAS= TGAS1+DTGAS
    GOTO 120
100 DIF= ABS(F1/QFLOW)
    IF (DIF.LT.0.002.AND.ABS(TGAS2-TGAS1).LT.2.) GOTO 130
    TGAS=(F1*TGAS2-F2*TGAS1)/(F1-F2)
    IF (K.GT.10.AND.F1.LT.0..AND.TGAS.GT.TGASP) GOTO 105
    IF (K.GT.10.AND.F1.GT.0..AND.TGAS.LT.TGASN) GOTO 105
    IF (TGAS.GT.TGASP.OR.TGAS.LT.TGASN) TGAS=(TGASP+TGASN)/2.
    IF (K.EQ.1.AND.KH.EQ.0) TGAS= TGAS1+10.
    IF (TGAS.GT.2000.) GOTO 110
    IF (TGAS.LT.(TAMB+30.)) GOTO 110
    IF (PLFUEL.AND.TGAS.LT.TBOIL) GOTO 110
    GOTO 120
105 TGAS= (TGASN+TGASP)/2.
    GOTO 120
110 SCAN= .TRUE.
    TGAS= 1900.
120 CONTINUE
    IF (K-200) 30,30,200
130 CONTINUE
    CALL RSTA
    FLREM= FLREM-RP*DTIME
    IF(FLREM.LT.0) FLREM=0.
    IF (QCONW.GT.0.) QWLSUM= QWLSUM+(QRADW+QCONW)*DTIME
    IF (TTIME .GE. MTIME) GO TO 210
    IF (TGAS.LE.353..AND.J.GE.10) GO TO 210
    IF (J.EQ.1) GO TO 150
    IF (JP.LT.JPRINT) GO TO 160
    JP= 0
150 CALL OUTPUT
160 JP= JP+1
    TTIME= TTIME+DTIME
```

```
  170 CONTINUE
C         END TIME STEP DO-LOOP
      RETURN
C         ERROR IN INPUT
  190 CONTINUE
      KNTRL= 2
      WRITE (2,910)
  910 FORMAT (///' PFLFIX ROUTINE DOES NOT ACCEPT STEADY-STATE CASE')
  195 CONTINUE
      IF(KTRACE.EQ.1) WRITE(2,930) TGAS,RC,RP,YPYR,ZW,RMA,MWOUT
  930 FORMAT (/' TGAS=',F5.0,' RC=',E10.4,' RP=',E10.4,
     1  ' YPYR=',E10.4,' ZW=',F6.4,' RMA=',E10.4,' MWOUT=',F6.1)
C         FAIL TO CONVERGE, ERROR EXIT
  200 CONTINUE
      KNTRL=3
      RETURN
C         FIRE IS OVER (TRANSIENT CASE)
  210 CONTINUE
      CALL OUTPUT
  220 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE POOL
C
C          PLASTIC FUEL (POOL FIRE) ROUTINE
C          FUEL 'SEES' ONLY COMPARTMENT AND NOT ITSELF
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,R0,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /QS/     QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/   BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1   WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,SCAN,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
C           Y- DENOTE MASS FRACTIONS OF OUTFLOW
C           RMA= MASS INFLOW RATE
C           RMF= MASS OUTFLOW RATE
C           R= STOICHIOMETRIC AIR/FUEL MASS RATIO
C           R0= STOICHIOMETRIC OXYGEN/FUEL RATIO
      SCAN= .FALSE.
C         INITIALIZES STOICHIOMETRIC CASE
      IF (STOICH) EITA =1.
      QRADW=0.
      QCONW= 0.
      F2=0.
      F1=0.
      DTGAS=10.
      TBOIL=TBOILC+273.
      FC= .FALSE.
      CALL HEADNG
      TF2= TGAS
C         START TIME STEP
      DO 170 J=1,JM
      KH= 0
      DERIV1= 1.
      TGAS2= 0.
      TGAS1= 0.
      TGASP= 2000.
      TGASN= TAMB
   20 CONTINUE
      K= 0
   30 CONTINUE
      IF (STOICH) GOTO 34
   32 RP= SIZE*EF*SIGMA*(TGAS**4.-TBOIL**4.)/DHP
      IF (STEADY) GOTO 33
```

```
      PLUME= SIZE*0.0014*CVNET/DHP
      PROP= 1.-(TGAS**4.-TBOIL**4.)/(1700.**4.-TBOIL**4.)
      IF (PROP.LT.0.) PROP= 0.
      RP= RP+PROP*PLUME
   33 CONTINUE
      RMF= RMA+RP
      IF(FLREM.LE.0)RP=0.
   34 YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
      IF(YPYR.LT..0) YPYR= 0.
      QFUEL= (RP-RC)*DHP
      MWOUT= 44.*YCO2+18.*YH2O+28.*YN2+32.*YO2+MWPYR*YPYR
      HRATIO= 1./(1.+((TGAS/TAMB)*(MWIN/MWOUT)*(1.+RP/RMA)**2)
     1   **0.3333333333)
C        NOTE HIN IS TAKEN AS POSITIVE
      HIN= HWDOW* HRATIO
      ZW=1.-MWOUT*TAMB/MWIN/TGAS
      IF(ZW)195,35,35
   35 VAVGIN= 0.666667*SQRT(2.*G*HIN*ZW)
      RMA= CD*VAVGIN*HIN*BWDOW*DENSA
      RMF= RMA+RP
      RC= BPF*RMA/R
      IF (STOICH) RP= RC/BPF
      IF ((EISCAN.AND.EITA.LT.1.).OR.STOICH) GOTO 37
   36 IF (RC.GT.RP*BPF) GOTO 40
   37 FC= .FALSE.
      GO TO 45
   40 FC= .TRUE.
      RC= RP*BPF
C        RECALCULATE VALUES IF IN FUEL CONTROL REGIME.
      YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
   45 CONTINUE
      QFLOW= RMF*(YCO2*(TGAS*(0.5*CPCO2(1)*TGAS+CPCO2(2))-TAMB*(0.5*
     1   CPCO2(1)*TAMB+CPCO2(2))) +YH2O*(TGAS*(0.5*CPH2O(1)*TGAS+
     2   CPH2O(2))-TAMB*(0.5*CPH2O(1)*TAMB+CPH2O(2))) +YO2*(TGAS*(
     3   0.5*CPO2(1)*TGAS+CPO2(2))-TAMB*(0.5*CPO2(1)*TAMB+CPO2(2)))
     4   +YN2*(TGAS*(0.5*CPN2(1)*TGAS+CPN2(2))-TAMB*(0.5*CPN2(1)*
     5   TAMB+CPN2(2))) +YPYR*(TGAS*(0.5*CPPYR(1)*TGAS+CPPYR(2))
     6   -TAMB*(0.5*CPPYR(1)*TAMB+CPPYR(2))))
      QFIRE= RC*CVNET
      IF (ADIA) GOTO 90
      IF (.NOT.STEADY) CALL DESOLV
      IF (STEADY) CALL STFLOW
      QRADW= AWALLN*EMS(1)*SIGMA*(TGAS**4.-TSF**4.)
      QCONW= AWALLN*(TGAS-TSF)*CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
   90 CONTINUE
      QRADO= AWDOW*SIGMA*(TGAS**4.-TAMB**4.)
      K= K+1
      F3=F2
      F2=F1
      F1= QFIRE-QFLOW-QFUEL-QRADO-QRADW-QCONW
```

```
      TGAS3=TGAS2
      TGAS2=TGAS1
      TGAS1=TGAS
      IF (F1.LT.0..AND.TGAS.LT.TGASP) TGASP=TGAS
      IF (F1.GT.0..AND.TGAS.GT.TGASN) TGASN=TGAS
      DERIV2= DERIV1
      IF (TGAS1.EQ.TGAS2) GOTO 130
      DERIV1=(F1-F2)/(TGAS1-TGAS2)
      IF (KTRACE.GT.0) WRITE (4,99) TGAS1,TGAS2,F1,F2,DERIV1,K,KD,
     1   KH,J,T2(1),TSF,QFIRE,QFLOW,QRADW,RP,RC
   99 FORMAT(2F9.2,3(1PE9.2),3I3,I5,2(0PF9.2),3(1PE10.3),2(0PF7.3))
      IF (.NOT.SCAN) GOTO 95
      IF (F1/F2.GE.0.0) GOTO 93
      SCAN= .FALSE.
      GOTO 100
   93 TGAS= TGAS-DTGAS
      IF (TGAS.LT.TAMB) GOTO 200
      IF (TGAS.LT.TBOIL.AND.(FLREM.GT.0.0)) GOTO 190
      GOTO 120
   95 IF (DERIV1.LT..0.AND.ABS(F2).GT..0001)GOTO 100
      IF(DERIV2.LT..0.AND.J.GT.2) GOTO 100
      TGAS= TGAS1+DTGAS
      GOTO 120
  100 DIF= ABS(F1/QFLOW)
      IF (DIF.LT.0.002.AND.ABS(TGAS2-TGAS1).LT.2.) GOTO 130
      TGAS=(F1*TGAS2-F2*TGAS1)/(F1-F2)
      IF (K.GT.10.AND.F1.LT.0..AND.TGAS.GT.TGASP) GOTO 105
      IF (K.GT.10.AND.F1.GT.0..AND.TGAS.LT.TGASN) GOTO 105
      IF (K.EQ.1.AND.KH.EQ.0) TGAS= TGAS1+10.
      IF (TGAS.GT.2000.) GOTO 110
      IF (TGAS.LT.(TAMB+30.)) GOTO 110
      IF (TGAS.LT.TBOIL.AND.(FLREM.GT.0.0)) GOTO 110
      GOTO 120
  105 TGAS= (TGASN+TGASP)/2.
      GOTO 120
  110 SCAN= .TRUE.
      TGAS= 1900.
  120 CONTINUE
      IF (STEADY.AND..NOT.ADIA) CALL STFLOW
      IF (K-200) 30,30,200
  130 IF (STEADY) GOTO 180
      CALL RSTA
      FLREM= FLREM-RP*DTIME
      IF(FLREM.LT.0) FLREM=0.
      IF (QCONW.GT.0.) QWLSUM= QWLSUM+(QRADW+QCONW)*DTIME
      IF (TTIME .GE. MTIME) GO TO 210
      IF (TGAS.LE.353..AND.J.GE.10) GO TO 210
      IF (J.EQ.1) GO TO 150
      IF (JP.LT.JPRINT) GO TO 160
      JP= 0
  150 CALL OUTPUT
  160 JP= JP+1
      TTIME= TTIME+DTIME
  170 CONTINUE
C        END TIME STEP DO-LOOP
  180 CONTINUE
      IF(.NOT.STOICH) GOTO 185
C        FIND STOICHIOMETRIC FUEL SIZE
```

```
      SIZE1= RP/(EF*SIGMA*(TGAS**4.-TBOIL**4.)/DHP)
  185 CALL OUTPUT
C         NORMAL EXIT WHEN STEADY.EQ.T
      RETURN
C         ERROR EXIT
  190 CONTINUE
      IF (KTRACE.EQ.1) WRITE (2,910) TGAS.
  910 FORMAT(///' TGAS.LT.TBOIL   TGAS=',F8.1,'   GO TO NEXT CASE'///)
      GOTO 200
C         SQUARE ROOT ERROR
  195 CONTINUE
      IF(KTRACE.EQ.1) WRITE(2,930) TGAS,RC,RP,YPYR,ZW,RMA,MWOUT
  930 FORMAT (/' TGAS=',F5.0,' RC=',E10.4,' RP=',E10.4,
     1  ' YPYR=',E10.4,' ZW=',F6.4,' RMA=',E10.4,' MWOUT=',F6.1)
C         FAIL TO CONVERGE, ERROR EXIT
  200 CONTINUE
      KNTRL=3
      RETURN
C         FIRE IS OVER (TRANSIENT CASE)
  210 CONTINUE
      CALL OUTPUT
      RETURN
      END
```

```
      SUBROUTINE PP
C
C        PLOTTING SUBROUTINE
C        THIS ROUTINE IS LEFT BLANK SINCE IT IS MACHINE-DEPENDENT
C
      ENTRY PLTRST
C        THIS ENTRY SETS UP THE INIALIZATION OF PLOTTING
      ENTRY DSTO
C        THIS ENTRY IS CALLED EACH TIME TO STORE A DATA POINT
      ENTRY DOUT
C        THIS IS THE LAST ENTRY FOR A GIVEN RUN
      RETURN
      END
```

```
      SUBROUTINE PVTFIX
C
C         PESSIMIZATION ROUTINE
C         FIXED VENTILATION,WORST POSSIBLE FUEL PYROLYSIS RATE.
C
      COMMON /CNSTS/   AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/      CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1    CPO2(2),CPPYR(2)
      COMMON /FUEL/    C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1    OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/      AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1    J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/   FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1    RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/   ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1    PRNT,STEADY,THICKW
      COMMON /QS/      QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/    DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1    NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/    BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1    WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1    PLOT,PNCH,RPSPEC,SCAN,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
      IF (STEADY) GOTO 190
      FC= .FALSE.
      SCAN= .FALSE.
      QRADW=0.
      QCONW= 0.
      F2=0.
      F1=0.
      DTGAS=10.
      CALL HEADNG
C           START TIME LOOP
      DO 170 J=1,JM
      KH= 0
      DERIV1= 1.
      TGAS2= 0.
      TGAS1= 0.
      TGASP= 2000.
      TGASN= TAMB
   20 CONTINUE
      K= 0
   30 CONTINUE
      IF (FLREM.GT.0.) GOTO 32
      RC= 0.
      RP= 0.
      FC= .TRUE.
   32 RMF= RMA+RP
      YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
      IF(YPYR.LT..0) YPYR= 0.
```

```
      MWOUT= 44.*YCO2+18.*YH2O+28.*YN2+32.*YO2+MWPYR*YPYR
      HRATIO= 1./(1.+((TGAS/TAMB)*(MWIN/MWOUT)*(1.+RP/RMA)**2)
     1   **0.3333333333)
C        NOTE HIN IS TAKEN AS POSITIVE
      HIN= HWDOW* HRATIO
      ZW=1.-MWOUT*TAMB/MWIN/TGAS
      IF(ZW)195,35,35
   35 VAVGIN= 0.666667*SQRT(2.*G*HIN*ZW)
      RMA= CD*VAVGIN*HIN*BWDOW*DENSA
      RMF= RMA+RP
      IF (.NOT.FC) RC= BPF*RMA/R
      IF (.NOT.FC) RP= RC/BPF
   45 CONTINUE
      QFLOW= RMF*(YCO2*(TGAS*(0.5*CPCO2(1)*TGAS+CPCO2(2))-TAMB*(0.5*
     1   CPCO2(1)*TAMB+CPCO2(2))) +YH2O*(TGAS*(0.5*CPH2O(1)*TGAS+
     2   CPH2O(2))-TAMB*(0.5*CPH2O(1)*TAMB+CPH2O(2))) +YO2*(TGAS*(
     3   0.5*CPO2(1)*TGAS+CPO2(2))-TAMB*(0.5*CPO2(1)*TAMB+CPO2(2)))
     4   +YN2*(TGAS*(0.5*CPN2(1)*TGAS+CPN2(2))-TAMB*(0.5*CPN2(1)*
     5   TAMB+CPN2(2))) +YPYR*(TGAS*(0.5*CPPYR(1)*TGAS+CPPYR(2))
     6   -TAMB*(0.5*CPPYR(1)*TAMB+CPPYR(2))))
      QFIRE= RC*CVNET
      IF (ADIA) GOTO 90
      CALL DESOLV
      QRADW= AWALLN*EMS(1)*SIGMA*(TGAS**4.-TSF**4.)
      QCONW= AWALLN*(TGAS-TSF)*CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
   90 CONTINUE
      QRADO= AWDOW*SIGMA*(TGAS**4.-TAMB**4.)
      K= K+1
      F3=F2
      F2=F1
      F1= QFIRE-QFLOW-QRADO-QRADW-QCONW
      TGAS3=TGAS2
      TGAS2=TGAS1
      TGAS1=TGAS
      IF (F1.LT.0..AND.TGAS.LT.TGASP) TGASP=TGAS
      IF (F1.GT.0..AND.TGAS.GT.TGASN) TGASN=TGAS
      DERIV2= DERIV1
      IF (TGAS1.EQ.TGAS2) GOTO 130
      DERIV1=(F1-F2)/(TGAS1-TGAS2)
      IF (KTRACE.GT.0) WRITE (4,99) TGAS1,TGAS2,F1,F2,DERIV1,K,KD,
     1   KH,J,T2(1),TSF,QFIRE,QFLOW,QRADW,RP,RC
   99 FORMAT(2F9.2,3(1PE9.2),3I3,I5,2(0PF9.2),3(1PE10.3),2(0PF7.3))
      IF (.NOT.SCAN) GOTO 95
      IF (F1/F2.GE.0.0) GOTO 93
      SCAN= .FALSE.
      GOTO 100
   93 TGAS= TGAS-DTGAS
      IF (TGAS.LT.TAMB) GOTO 200
      GOTO 120
   95 IF (DERIV1.LT..0.AND.ABS(F2).GT..0001)GOTO 100
      IF(DERIV2.LT..0.AND.J.GT.2) GOTO 100
      TGAS= TGAS1+DTGAS
      GOTO 120
  100 DIF= ABS(F1/QFLOW)
      IF (DIF.LT.0.002.AND.ABS(TGAS2-TGAS1).LT.2.) GOTO 130
      TGAS=(F1*TGAS2-F2*TGAS1)/(F1-F2)
      IF (K.GT.10.AND.F1.LT.0..AND.TGAS.GT.TGASP) GOTO 105
      IF (K.GT.10.AND.F1.GT.0..AND.TGAS.LT.TGASN) GOTO 105
```

```
      IF (K.EQ.1.AND.KH.EQ.0) TGAS= TGAS1 +10.
      IF (TGAS.GT.2000.) GOTO 110
      IF (TGAS.LT.(TAMB+30.)) GOTO 110
      GOTO 120
  105 TGAS= (TGASN+TGASP)/2.
      GOTO 120
  110 SCAN= .TRUE.
      TGAS= 1900.
  120 CONTINUE
      IF (K-200) 30,30,200
  130 CONTINUE
      CALL RSTA
      FLREM= FLREM-RP*DTIME
      IF(FLREM.LT.0) FLREM=0.
      IF (QCONW.GT.0.) QWLSUM= QWLSUM+(QRADW+QCCNW)*DTIME
      IF (TTIME .GE. MTIME) GO TO 210
      IF (TGAS.LE.353..AND.J.GE.10) GO TO 210
      IF (J.EQ.1) GO TO 150
      IF (JP.LT.JPRINT) GO TO 160
      JP= 0
  150 CALL OUTPUT
  160 JP= JP+1
      TTIME= TTIME+DTIME
  170 CONTINUE
C         END TIME STEP DO-LOOP
      RETURN
C         ERROR IN INPUT
  190 CONTINUE
      KNTRL= 2
      WRITE (2,910)
  910 FORMAT (///' PVTFIX ROUTINE DOES NOT ACCEPT STEADY-STATE CASE')
      RETURN
C         SQUARE ROOT ERROR
  195 CONTINUE
      IF(KTRACE.EQ.1) WRITE(2,930) TGAS,RC,RP,YPYR,ZW,RMA,MWOUT
  930 FORMAT (/' TGAS=',F5.0,' RC=',E10.4,' RP=',E10.4,
     1  ' YPYR=',E10.4,' ZW=',F6.4,' RMA=',E10.4,' MWOUT=',F6.1)
C         FAIL TO CONVERGE, ERROR EXIT
  200 CONTINUE
      KNTRL=3
      RETURN
C         FIRE IS OVER (TRANSIENT CASE)
  210 CONTINUE
      CALL OUTPUT
      RETURN
      END
```

```
      SUBROUTINE RPFIX
C
C
C        TABULAR FUEL PYROLYSIS ROUTINE
C        FUEL PYROLYSIS RATE IS AN INPUT VARIABLE.
C
      COMMON /CNSTS/  AWALLN,BWDOW,DENSA,G,GASCNT,KTRACE,MTIME
      COMMON /CP/     CPA,CPCO(2),CPCO2(2),CPH2(2),CPH2O(2),CPN2(2),
     1   CPO2(2),CPPYR(2)
      COMMON /FUEL/   C,CFLPC,CVGROS,CVNET,H,HFLPC,MWPYR,N,NFLPC,O,
     1   OFLPC,R,RO,REGRES,SH,SHAPE,SIZE,W,WFLPC,WTFUEL
      COMMON /GP/     AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /LOGIC/  FC,FLSPEC,KRIT,NEWPLT,NEWPRP,PLFUEL,PLOT,PNCH,
     1   RPSPEC,VTSPEC
      COMMON /PLAST/ TBOILC,DHP,STOICH,SIZE1,EITA,EISCAN
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /QS/     QCONW,QFIRE,QFLOW,QRADO,QRADW,QWLSUM
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
      COMMON /WOUT/   BWORST,FLREM,HRATIO,RMA,RMF,TTIME,VAVGIN,
     1   WA,WB,YCO2,YH2O,YN2,YO2,YPYR
      LOGICAL ADIA,EISCAN,FC,FLSPEC,KRIT,NEWPRP,PLFUEL,
     1   PLOT,PNCH,RPSPEC,SCAN,STEADY,STOICH,VTSPEC
      REAL MWIN,MWOUT,MWPYR,MTIME,N,NFLPC
      SCAN= .FALSE.
      QRADW=0.
      QCONW= 0.
      F2=0.
      F1=0.
      DTGAS=10.
      CALL HEADNG
C         START TIME LOOP
      DO 170 J=1,JM
      KH= 0
      DERIV1= 1.
      TGAS2= 0.
      TGAS1= 0.
      TGASP= 2000.
      TGASN= TAMB
   20 CONTINUE
      K= 0
   30 CONTINUE
      FC= .FALSE.
      IF (FLREM.GT.0.) RP= TLU(RPX,NRP,TTIME)
      IF (FLREM.LE.0.) RP= 0.
      RMF= RMA+RP
      YCO2= 3.66667*CFLPC*RC/100./RMF
      YH2O= (WFLPC*RP+9.0*HFLPC*RC)/100./RMF
      YO2= (0.23*RMA-RO*RC)/RMF
      YN2= 0.77*RMA/RMF +NFLPC*RP/100./RMF
      YPYR= (RP-RC)/RMF
      IF(YPYR.LT..0) YPYR= 0.
      MWOUT= 44.*YCO2+18.*YH2O+28.*YN2+32.*YO2+MWPYR*YPYR
      HRATIO= 1./(1.+((TGAS/TAMB)*(MWIN/MWOUT)*(1.+RP/RMA)**2)
```

```
      1    **0.3333333333)
C          NOTE HIN IS TAKEN AS POSITIVE
      HIN= HWDOW* HRATIO
      ZW=1.-MWOUT*TAMB/MWIN/TGAS
      IF(ZW)195,35,35
   35 VAVGIN= 0.666667*SQRT(2.*G*HIN*ZW)
      RMA= CD*VAVGIN*HIN*BWDOW*DENSA
      RMF= RMA+RP
      IF (RMA/R-RP) 40,40,45
   40 RC= BPF*RMA/R
      GO TO 50
   45 RC= BPF*RP
      FC= .TRUE.
   50 CONTINUE
      QFLOW= RMF*(YCO2*(TGAS*(0.5*CPCO2(1)*TGAS+CPCO2(2))-TAMB*(0.5*
     1    CPCO2(1)*TAMB+CPCO2(2))) +YH2O*(TGAS*(0.5*CPH2O(1)*TGAS+
     2    CPH2O(2))-TAMB*(0.5*CPH2O(1)*TAMB+CPH2O(2))) +YO2*(TGAS*(
     3    0.5*CPO2(1)*TGAS+CPO2(2))-TAMB*(0.5*CPO2(1)*TAMB+CPO2(2)))
     4    +YN2*(TGAS*(0.5*CPN2(1)*TGAS+CPN2(2))-TAMB*(0.5*CPN2(1)*
     5    TAMB+CPN2(2))) +YPYR*(TGAS*(0.5*CPPYR(1)*TGAS+CPPYR(2))
     6    -TAMB*(0.5*CPPYR(1)*TAMB+CPPYR(2))))
      QFIRE= RC*CVNET
      IF (ADIA) GOTO 90
      IF (.NOT.STEADY) CALL DESOLV
      IF (STEADY) CALL STFLOW
      QRADW= AWALLN*EMS(1)*SIGMA*(TGAS**4.-TSF**4.)
      QCONW= AWALLN*(TGAS-TSF)*CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
   90 CONTINUE
      QRADO= AWDOW*SIGMA*(TGAS**4.-TAMB**4.)
      K= K+1
      F3=F2
      F2=F1
      F1= QFIRE-QFLOW-QRADO-QRADW-QCONW
      TGAS3=TGAS2
      TGAS2=TGAS1
      TGAS1=TGAS
      IF (F1.LT.0..AND.TGAS.LT.TGASP) TGASP=TGAS
      IF (F1.GT.0..AND.TGAS.GT.TGASN) TGASN=TGAS
      DERIV2= DERIV1
      IF (TGAS1.EQ.TGAS2) GOTO 130
      DERIV1=(F1-F2)/(TGAS1-TGAS2)
      IF (KTRACE.GT.0) WRITE (4,99) TGAS1,TGAS2,F1,F2,DERIV1,K,KD,
     1    KH,J,T2(1),TSF,QFIRE,QFLOW,QRADW,RP,RC
   99 FORMAT(2F9.2,3(1PE9.2),3I3,I5,2(0PF9.2),3(1PE10.3),2(0PF7.3))
      IF (.NOT.SCAN) GOTO 95
      IF (F1/F2.GE.0.0) GOTO 93
      SCAN= .FALSE.
      GOTO 100
   93 TGAS= TGAS-DTGAS
      IF (TGAS.LT.TAMB) GOTO 200
      GOTO 120
   95 IF (DERIV1.LT..0.AND.ABS(F2).GT..0001)GOTO 100
      IF(DERIV2.LT..0.AND.J.GT.2) GOTO 100
      TGAS= TGAS1+DTGAS
      GOTO 120
  100 DIF= ABS(F1/QFLOW)
      IF (DIF.LT.0.002.AND.ABS(TGAS2-TGAS1).LT.2.) GOTO 130
      TGAS=(F1*TGAS2-F2*TGAS1)/(F1-F2)
```

```
      IF (K.GT.10.AND.F1.LT.0..AND.TGAS.GT.TGASP) GOTO 105
      IF (K.GT.10.AND.F1.GT.0..AND.TGAS.LT.TGASN) GOTO 105
      IF (K.EQ.1.AND.KH.EQ.0) TGAS= TGAS1+10.
      IF (TGAS.GT.2000.) GOTO 110
      IF (TGAS.LT.(TAMB+30.)) GOTO 110
      GOTO 120
  105 TGAS= (TGASN+TGASP)/2.
      GOTO 120
  110 SCAN= .TRUE.
      TGAS= 1900.
  120 CONTINUE
      IF (STEADY.AND..NOT.ADIA) CALL STFLOW
      IF (K-200) 30,30,200
  130 CONTINUE
      IF (STEADY) GOTO 180
      CALL RSTA
      FLREM= FLREM-RP*DTIME
      IF(FLREM.LT.0.) FLREM=0.
      IF (QCONW.GT.0.) QWLSUM= QWLSUM+(QRADW+QCONW)*DTIME
      IF (TTIME .GE. MTIME) GO TO 210
      IF (TGAS.LE.353..AND.J.GE.10) GO TO 210
      IF (J.EQ.1) GO TO 150
      IF (JP.LT.JPRINT) GO TO 160
      JP= 0
  150 CALL OUTPUT
  160 JP= JP+1
      TTIME= TTIME+DTIME
  170 CONTINUE
C        END TIME STEP DO-LOOP
  180 CONTINUE
  185 CALL OUTPUT
C        NORMAL EXIT WHEN STEADY.EQ.T
      RETURN
C        SQUARE ROOT ERROR
  195 CONTINUE
      IF(KTRACE.EQ.1) WRITE(2,930) TGAS,RC,RP,YPYR,ZW,RMA,MWOUT
  930 FORMAT (/' TGAS=',F5.0,' RC=',E10.4,' RP=',E10.4,
     1  ' YPYR=',E10.4,' ZW=',F6.4,' RMA=',E10.4,' MWOUT=',F6.1)
C        FAIL TO CONVERGE, ERROR EXIT
  200 CONTINUE
      KNTRL=3
      RETURN
C        FIRE IS OVER (TRANSIENT CASE)
  210 CONTINUE
      CALL OUTPUT
      RETURN
      END
```

```
      SUBROUTINE STFLOW
C
C           CALCULATES WALL HEAT CONDUCTION WHEN STEADY-STATE
C           CONDITION ONLY IS NEEDED.
C
      COMMON /GP/      AWDOW,BPF,CD,CNV,DTIME,EMS(2),HWDOW,IX,IXC,IXL,
     1   J,JM,JP,JPRINT,K,KD,KH,KITER,KNTRL,MWIN,MWOUT,RC,RP,SIGMA
      COMMON /PRBLM/  ADIA,AFLOOR,AWALL,DENSW,FLOAD,IRUN,OPENF,
     1   PRNT,STEADY,THICKW
      COMMON /TEMP/   DENF,DENU,TAMB,TGAS,TINPT,T1(20),T2(20),TSF,TSU
      COMMON /THERML/ CNDA(2,10),CPW(2,10),DX,EF,EMSA(2,10),
     1   NCND,NCPW,NEMS,NQGEN,NRP,QGEN(2,10),RPX(2,50)
C        BIOT= BIOT NUMBER
      KD= 0
      TSF= TGAS -30.
      TSU= TAMB +30.
   10 CONTINUE
      TSFOLD= TSF
      TSUOLD= TSU
      EMS(1)= 1./(1./TLU(EMSA,NEMS,TSF) +1./EF -1.)
      EMS(2)= TLU(EMSA,NEMS,TSU)
      TAVG= (TGAS+TAMB)/2.
      CND= TLU(CNDA,NCND,TAVG)
      ZRF= TGAS*(TGAS*(TGAS+TSF)+TSF*TSF)+TSF*TSF*TSF
      ZCF= CNV*((TGAS-TSF)*(TGAS-TSF))**0.16666667
      HF= ZCF+EMS(1)*SIGMA*ZRF
      BIOTF= HF*THICKW/CND
      ZRU= TAMB*(TAMB*(TAMB+TSU)+TSU*TSU)+TSU*TSU*TSU
      ZCU= 1.31*((TAMB-TSU)*(TAMB-TSU))**0.16666667
      HU= ZCU+EMS(2)*SIGMA*ZRU
      BIOTU= HU*THICKW/CND
      TSF= ((BIOTF+HF/HU)*TGAS+TAMB)/(1.+BIOTF+HF/HU)
      TSU= ((BIOTU+HU/HF)*TAMB+TGAS)/(1.+BIOTU+HU/HF)
      T2(1)= TSF- (TSF-TSU)*DX/THICKW/2.
      T2(IXC)= (TSF+TSU)/2.
      IF ((ABS(TSF-TSFOLD).LT.3.).AND.(ABS(TSU-TSUOLD).LT.3.))
     1   RETURN
      KD= KD+1
      TSU= (TSU+TSUOLD)/2.
      IF (KD.LT.20) GOTO 10
      WRITE (2,90) TSF,TSFOLD
   90 FORMAT (//' **UNSUCCESSFUL ITERATION IN STFLOW'/
     1   '     TSF=',F15.2,'  TSFOLD=',F15.2)
      RETURN
      END
```

```
      FUNCTION TLU (ARRAY,NUM,VALIN)
C        TABULAR LOOK-UP INTERPOLATING ROUTINE
C
      DIMENSION ARRAY(2,NUM)
C        ARRAY(1,I)= INDEPENDENT VARIABLE
C        ARRAY(2,I)= DEPENDENT VARIABLE
C        INTERPOLATES LINEARLY WITHIN GIVEN DOMAIN.  SETS EQUAL TO
C        SMALLEST OR LARGEST VALUE IF OUTSIDE THE DOMAIN.
      IF (NUM.NE.1) GO TO 10
      TLU= ARRAY(2,1)
      RETURN
   10 IF (NUM.NE.2) GO TO 20
      I= 2
      GO TO 50
   20 IF (VALIN.GT.ARRAY(1,1)) GO TO 30
      TLU= ARRAY(2,1)
      RETURN
   30 DO 40 I=2,NUM
      IF (VALIN.LE.ARRAY(1,I)) GO TO 50
   40 CONTINUE
      TLU= ARRAY(2,NUM)
      RETURN
   50 TLU= ARRAY(2,I-1) + (VALIN - ARRAY(1,I-1))*
     1   ((ARRAY(2,I) - ARRAY(2,I-1)) / (ARRAY(1,I) - ARRAY(1,I-1)))
      RETURN
      END
```

```
      SUBROUTINE TRIDGF (A,B,C,D,E,IX)
C
C        TRIDIAGONAL GAUSS ELIMINATION PROCEDURE FOR UNSYMMETRIC
C        MATRICES.
C        A=LEFT OF DIAGONAL, B=DIAGONAL, C=RIGHT OF DIAGONAL,
C        D= CONSTANT VECTOR, E= SOLUTION VECTOR, IX= SIZE OF MATRIX.
C
      DIMENSION A(20),B(20),C(20),D(20),E(20),CP(20)
      CP(1)= C(1)/B(1)
      E(1)= D(1)/B(1)
      C(IX)= 0.
      IXL= IX-1
      DO 10 I=2,IX
      J= I-1
      BX= B(I)-CP(J)*A(I)
      CP(I)= C(I)/BX
      E(I)= (D(I)-E(J)*A(I))/BX
   10 CONTINUE
      DO 20 I=1,IXL
      J= IX-I
      E(J)= E(J)-E(J+1)*CP(J)
   20 CONTINUE
      RETURN
      END
```

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

COMPF2 is a computer program for calculating the characteristics of a post-flashover fire in a single building compartment, based on fire-induced ventilation through a single door or window. It is intended both for performing design calculations and for the analysis of experimental burn data. Wood, thermoplastic, and liquid fuels can be treated. In addition to the capability of performing calculations for compartments with completely determined properties, routines are included for calculating fire behavior by an innovative variable abstraction method. A comprehensive output format is provided which gives gas temperatures, heat flow terms, and flow variables. The documentation includes input instructions, sample problems, and a listing of the program. The program is written in Fortran and constitutes an improved version of an earlier program, COMPF.

17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)

Computer programs--fire protection; fire protection; fire resistance; fire tests; fire walls; safety engineering--fires.

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